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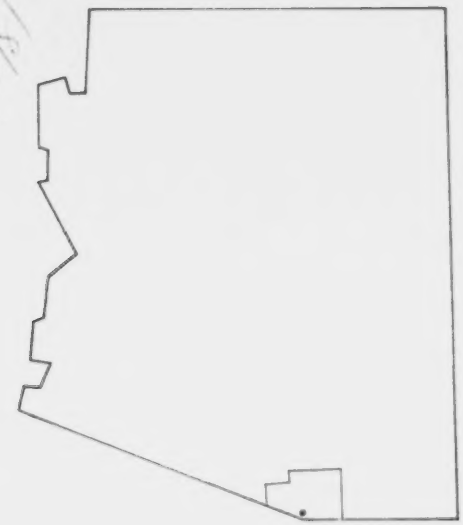
FLOOD INSURANCE STUDY



CITY OF NOGALES, ARIZONA
SANTA CRUZ COUNTY

OCTOBER 15,1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER -040091

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Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the City of Nogales, Santa Cruz County, Arizona, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Nogales to the regular program of flood insurance by the Federal Insurance Administration. Further use of the information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

This study was made in conjunction with similar Flood Insurance Studies being conducted by the U.S. Soil Conservation Service for the unincorporated areas of Santa Cruz County, Arizona, and for the Town of Patagonia, Arizona (References 1 and 2, respectively).

Community base map selection and the identification of streams requiring detailed study were made at a meeting attended by personnel of the U.S. Soil Conservation Service, the Federal Insurance Administration, the Arizona State Land Department, the Planning Department of Santa Cruz County, and the Public Works Department of the City of Nogales on March 28, 1975.

During the course of the work, flood elevations, flood boundaries and floodway delineations were reviewed with community officials and the concerned public, and with representatives of the Arizona State Land Department and the Federal Insurance Administration. Specific meetings for this purpose were held on November 23, 1976, and April 7, 1977.

The U.S. Army Corps of Engineers, the U.S. Geological Survey, the Arizona Water Commission, the National Weather Service, the U.S. Bureau of Land Reclamation, and the International Boundary and Water Commission were also consulted during the course of this study.

The results of this study were reviewed at a final community coordination meeting held on October 10, 1978. Attending the meeting were representatives of the Federal Insurance Administration, the study contractor, the Arizona State Land Department, the Santa Cruz County Department of Planning and Zoning, and the City of Nogales. This study incorporates all appropriate comments and all problems have been resolved.

In January 1979 an appeal to the Santa Cruz County Flood Insurance Study (Reference 1) was submitted by the Santa Cruz County Board of Supervisors concerning areas that have since been annexed into the City of Nogales. The appeal has been resolved without change to this Flood Insurance Study.

A report titled "Review of Flood Hazard and Flood Plain Study for Nogales Wash" (Reference 3) was submitted with the Santa Cruz County appeal of January 1979. The report reviewed the hydrologic methods used to compute 100-year peak floods for ungaged study areas. The report was reviewed and found to present no technical data to refute the discharges determined for this Flood Insurance Study.

1.3 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by the U.S. Soil Conservation Service, for the Federal Insurance Administration, under the following Inter-Agency Agreement and Project Numbers:

Agreement No.	Project No.
IAA-H-18-75	2
IAA-H-18-75	8 (As Amended)
IAA-H-9-76	5
IAA-H-8-77	19

This work, which was completed in March 1978, covered all significant flooding sources affecting the City of Nogales.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Nogales, Santa Cruz County, Arizona. The area of study is shown on the Vicinity Map (Figure 1). Land belonging to the State of Arizona, within the corporate limits, was not included in the study.

Floods caused by overflow of Potrero Creek, Nogales Wash (including State Highway 82 and Arroyo Boulevard channels and covered floodways), Mariposa Canyon and its tributaries, Ephriam Canyon Wash, Falls Wash, the flood plain area lying west of Arroyo Boulevard between Walnut and Quarry Streets, and the International Boundary Channel were studied in detail. Flooding on several smaller unnamed stream locations within Nogales were analyzed by approximate methods. Approximate methods were used in accord with decisions made by officials of the City of Nogales and representatives of the Federal Insurance Administration and the U.S. Soil Conservation Service. The decision was based primarily upon consideration of the size of the contributing drainage areas and upon past flood history.

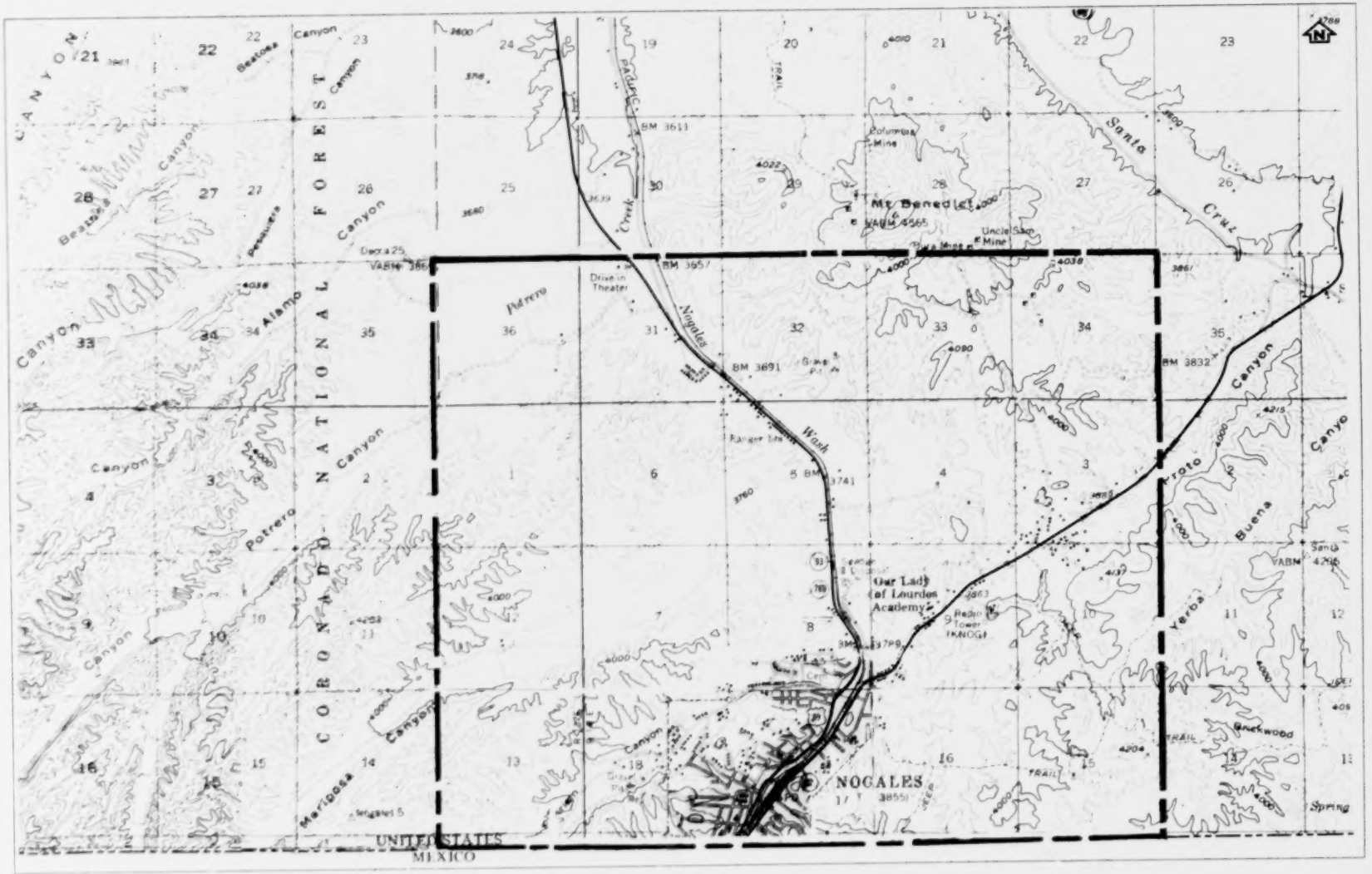

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

APPROXIMATE SCALE

1 0 1 2 3 MILES

VICINITY MAP

Projected changes to the community were considered not to have a significant impact upon hydrologic or hydraulic characteristics of the area. Therefore, only those factors derived from present conditions were used in the flood plain study.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1983.

2.2 Community Description

The City of Nogales is located in southern Santa Cruz County in south-central Arizona. It is located 64 miles south of the City of Tucson and is adjacent to the United States-Mexico border. The nearest American community is the Town of Patagonia, 19 miles to the northeast. Located across the United States-Mexico border from Nogales, Arizona, is the City of Nogales, Sonora, Mexico.

The combined population of these twin cities is over 110,000, but only approximately 11,000 reside in Nogales, Arizona. The general economy is supported by international commerce, government, manufacturing, construction, agriculture, and tourism (Reference 4).

The scenic hills and small valleys of the Nogales vicinity are covered with desert shrubs and grasses such as mesquite, scrub oak, ocotillo, creosote, and a mesquite-grass combination.

Soils of the Nogales area are primarily shallow and rocky, with rocks mostly of andesite and rhyolite tuffs, granites, and small areas of clay shale. On the east side of the city, rock outcrop and very shallow loamy soils are found. West of Nogales the soils are moderately deep to deep, but many are strongly calcareous and contain more than 35 percent by volume of gravel and cobble.

The study area is characterized by a warm, dry, steppe climate. Summer highs seldom exceed 100°F, and no month has an average temperature above 80°F. Winters are also mild, with no temperature below 0°F having ever been recorded. The average minimum temperature during the winter is 32°F, and the average winter maximum is 66°F. The average annual rainfall varies between 16 inches in low valley areas and 20 inches in the higher elevations of the watershed. More than one-half of the area's annual rainfall occurs during the summer rainy season in July and August. These summer rains often come as brief torrential showers.

Winter precipitation is generally less intense but lasts longer than summer precipitation. Occasionally, tropical storms move inland, generally in September, and contribute large amounts of precipitation. It is from these latter storms that extreme flood events occur on the larger drainage areas. Summer thunderstorm activity is the usual cause of major flooding on the smaller tributary streams.

The development pattern of Nogales has placed most of the commercial areas in the lower portions of the city and the residential development mainly in the surrounding hills. Some residential development, however, has also occurred in the flood plain areas of the city. This is especially true on Ephriam Canyon and on the east side of Nogales Wash from Wayside Drive north to the Bankard Avenue area.

While the established portion of the city is fully developed, recent annexations have brought several areas of intense development within the corporate limits. The flood plains of Nogales Wash, Potrero Creek, Mariposa Canyon, and Ephriam Canyon Wash are being developed for both residential and commercial purposes.

Several large produce warehouses are located along Nogales Wash, from its confluence with Mariposa Canyon downstream to the Southern Pacific Railroad crossing. New residential and apartment dwelling complexes have been constructed in the flood plains of Nogales Wash and Potrero Creek near their point of confluence just north of the newly-established corporate limits.

Another new development that has been constructed in the last few years is a shopping center at the mouth of Mariposa Canyon. Further development on this tributary is imminent.

A new Port of Entry into Mexico near Ephriam Canyon Wash will encourage future development in this area.

Streamflow in all surface drainage affecting the city is ephemeral. Nogales Wash, the major drainage system for the city, originates in Mexico and enters Nogales, Arizona, as a covered floodway. The covered floodway begins approximately 1 mile south of the International Boundary and outlets near the confluence of Nogales Wash with the Arroyo Boulevard Channel.

The Arroyo Boulevard Channel also begins as a covered floodway in Mexico and has two main entrances. One is located beneath an old hotel situated in the flood plain of Nogales Wash, approximately 400 feet south of the International Boundary. This entrance collects water from local runoff and from floodflows which exceed the capacity of the Nogales Wash Covered Floodway. The second entrance is located adjacent to the International Boundary approximately 550 feet west of the United States-Mexico Border Station on Grand Avenue.

Immediately upsteam of the second entrance, there are 4-foot high walls on each side of the channel. These walls effectively prevent any local runoff from entering the covered floodway; thus, flow at this entrance is limited to that which originates from the drainage area of the International Boundary Channel.

Although both the Nogales Wash and Arroyo Boulevard Covered Floodways have highway and street inlets along their courses, these have limited capacities and are ineffective in discharging large floodflows.

Because the covered floodways are limited by their size and entrance conditions, any flood exceeding the capacity of either of these restrictions will be discharged as overland flow along the streets of the twin cities.

Overland flows originating in Mexico also have two possible flow paths. They can either pass through the Grand Avenue or International Street openings and continue downstream along Grand Avenue, or they can overtop the Southern Pacific Railroad just south of the Border Station and flow east and then north along Morley Avenue. The two overland flow paths rejoin downstream near Court Street.

Just downstream of Court Street, overland flows can overtop Arroyo Boulevard and flow north along its west side, entering a series of culverts located in this area between Walnut and Quarry Streets. The flows entering the culverts are discharged into the Arroyo Boulevard Covered Floodway. These culverts also serve to provide drainage from local runoff originating west of the boulevard.

Downstream of the covered floodway outlets, floodflows are conveyed through the city in concrete-lined channels. Along certain reaches of these channels, there are parapet walls on each side which are approximately 1 to 2 feet high. These walls effectively increase the capacities of the channels, but they also prevent local runoff from entering the channels except at certain locations.

The main east-west drainage systems in the city are Potrero Creek, Mariposa Canyon, Ephriam Canyon Wash, and Falls Wash. Potrero Creek flows northeasterly from the Coronado National Forest, joins Nogales Wash just east of U.S. Highway 89 outside the corporate limits, and proceeds north paralleling the highway to its confluence with Santa Cruz River. Mariposa Canyon and Ephriam Canyon Wash rise in Sonora, Mexico, and flow in a northeasterly direction to their confluence with Nogales Wash. Falls Wash rises in the hilly terrain to the east of the city and flows in a northwesterly direction, intersecting Nogales Wash just north of State Highway 82.

The State Highway 82 Tributary and two other small tributaries located east of Nogales Wash opposite Ephriam Canyon Wash also cause some flood problems in the northeastern part of the city. The drainage system on State Highway 82 Tributary and Covered Floodway within the corporate limits consists of a covered floodway located beneath the highway, and an open, rock-walled channel which serves as its outlet. There are no channels in the two small tributaries located east of Nogales Wash opposite Ephriam Canyon Wash. Floodflows through the residential section located in this area are carried by curbed streets.

Several other small tributary streams are scattered throughout the city and cause minor flood problems.

2.3 Principal Flood Problems

Prior to the installation of the flood control channels in Nogales, Arizona, and Nogales, Sonora, Mexico, flood damage in these twin cities was frequent and severe. Repeated damages to structures in the Nogales Wash flood plain were reported in 1891, 1897, 1905, 1908, 1917, 1922, 1927, and 1930.

The August 8, 1930 flood was one of the most severe to hit the twin cities. This flood resulted in the loss of several lives and heavy property damages. After the 1930 flood, the Nogales Wash Covered Floodway and the open, concrete-lined channels were installed. Portions of the Arroyo Boulevard Covered Floodway had been installed prior to the 1930 flood.

Since the installation of the flood control channels, flood problems along Nogales Wash have been slight. Present flood problems in the Nogales Wash area generally consist of shallow flooding along the streets and roadways because of the inability of local runoff to enter the covered floodways.

When a 100-year flood occurs on the Nogales Wash drainage, the capacity of the covered floodways will be exceeded and overland flows will inundate the upstream areas of the city. Downstream of the covered floodways, the open, concrete-lined channels generally have sufficient capacity to carry the 100-year flood.

In the Ephriam Canyon Wash area, no information is available on floods prior to 1914, or on floods that might have occurred in the wash between 1930 and 1954. Floods are reported to have occurred in Ephriam Canyon Wash in 1914, 1915, 1926, and 1930. In 1954, a small flood occurred in the canyon, but no overflow occurred. Several other small floods, with only minor overflows, have occurred in Ephriam Canyon since 1954. Little data is available on the damages caused by any of these floods. A flood on July 3, 1975 nearly overtopped the Ephriam Canyon banks at several points. At the Western Avenue Bridge, the culverts were almost clogged by debris.

The likelihood of the bridge being blocked in the future is high, due to the location of a car junkyard just upstream of the bridge. Should the bridge become completely plugged, floodwaters would be forced out of the channel onto the south flood plain, inundating homes and apartment buildings.

Major factors that aggravate flood problems on Nogales Wash and Ephriam Canyon Wash include debris and vegetative growth in the channel; siltation of the stream channels, culverts and bridge openings, including poor entrance conditions into the covered floodways; and inadequate road and railroad openings.

On Ephriam Canyon Wash, a high roadfill and culverts greatly affect the larger floods. This roadfill is located on the new truck route (State Highway 189). Flows at this location are ponded to great depths on the upstream side of the embankment, with a resulting decrease in peak discharges on the downstream side. Both these effects were evaluated in the Flood Insurance Study.

Flows on Nogales Wash are affected by a bridge connecting U.S. Highway 89 and Bankard Avenue, a low-water ford and culverts on Baffert Drive, the Southern Pacific Railroad bridge, and the Old Tucson Highway bridge located near the Nogales Wash-Potrero Creek confluence just north of the corporate limits. A large drop in channel bottom grade also occurs at the Old Tucson Highway bridge crossing. A similar drop in the Nogales Wash channel bottom profile can be noted at the first road crossing located downstream of the Southern Pacific Railroad bridge.

The bridge located 4.048 miles upstream from the mouth of Nogales Wash is a twin concrete box structure which is smaller than the concrete-lined channel over which it crosses. Thus, the bridge constricts the flow, forcing water onto the adjacent flood plains. The floodflow returns to the channel a short distance downstream. The culverts on Baffert Drive are small and have a very limited capacity. During large floods, the low water ford serves as a weir and tends to decrease the total capacity of the channel.

The Southern Pacific Railroad embankment that lies in the Nogales Wash flood plain significantly affects floodflows on this stream, as does the embankment of U.S. Highway 89. Flows on the wash are diverted by the highway and railroad embankments, causing the water to be confined to only a portion of the total valley cross section. With further constriction due to development in the flood plain, as well as the bridge constrictions, flows exceeding the 50-year discharge will tend to overtop the railroads and highways and inundate the flood plains on the west side of the embankments opposite the channel. Flood elevations west of the railroad and highways generally are not as high as floodwaters confined to the channel side of the flood plain. Plotted cross sections C and K (Exhibit 2) show typical flow conditions on Nogales Wash as described above.

Flows on Potrero Creek are affected by a severe constriction at the Interstate Highway 19 bridge. On Mariposa Canyon, two new road crossings have been installed in conjunction with the construction of a new truck route (State Highway 189) bypassing the Cities of Nogales, Sonora, Mexico and Nogales, Arizona. Although the bridges for these crossings were constructed to carry the 100-year flood without overtopping, some backwater conditions are created upstream of the structures. Also, the upper roadway will be overtopped with the occurrence of the 500-year flood.

A major constriction to flow on Mariposa Canyon is that of Interstate Highway 19. With flows of large magnitude, extreme depths of flooding can occur at this location. Also, on the lower reaches of Mariposa Canyon, flow depths are increased due to limited capacities of the U.S. Highway 89 and Southern Pacific Railroad bridges. At this location, a new shopping center has also encroached upon the flood plain of Mariposa Canyon.

Flooding on Falls Wash is aggravated by the State Highway 82 roadfill and culvert and by the constriction of the culverts on Morley Avenue. Because of the channel hydraulics on this stream, a hydraulic jump is formed in the channel downstream of State Highway 82 and, under certain conditions, water is forced out of the channel onto the adjacent flood plains. These waters inundate the Arizona Highway Department's maintenance yard and buildings and other developments located in this area. When a 100-year flood occurs on Falls Wash, the capacity of the culvert beneath State Highway 82 will be exceeded, and floodwaters will overtop the levee located at the upstream end of the culvert. Floodwaters will be discharged downstream along the south side of the highway.

On the west side of Arroyo Boulevard, between Walnut and Quarry Streets, there is a low-lying area that is subject to inundation by local runoff from the west and by overland flows which overtop the boulevard from the east. Usually, the drainage system in this area is adequate to handle the local runoff situation but will be subject to damaging flood depths when the 100-year flood occurs on the upstream drainage area of Nogales Wash.

Major flooding along the lower reaches of the International Boundary Channel will result from overflow of the Nogales Wash Covered Floodway, although some flooding can also occur from overtopping of the International Boundary Channel. Should there be a breach in the rock walls along the International Boundary Channel (which has occurred in the past), the frequency of flooding downstream of the breach would be greatly increased, but the depths would be shallow.

On the State Highway 82 Tributary and Covered Floodway and on the two small tributaries located east of Nogales Wash opposite Ephriam Canyon, flooding is aggravated by improperly designed drainage systems. Although the open channel at the outlet end of the State Highway 82 Tributary has sufficient capacity to carry approximately the 100-year flood, shallow flooding will occur along the flood plains in this reach because proper inlets have not been provided.

On the two small tributaries located opposite Ephriam Canyon Wash, there are no channels, and floodwaters are conveyed through the area by curbed streets. In certain locations, the floor elevations of some of the houses are actually below the bottom of the curb, and

once the capacity of the curbed streets is exceeded, the floors of these houses are subject to inundation. Flood depths, however, generally will be less than 1 foot, as the peak discharges from these areas are small.

Figures 2 through 9 depict past floods and flood stages at various locations in the City of Nogales.

2.4 Flood Protection Measures

The main flood protection structures that provide a significant level of protection from major floods consist of the Nogales Wash and the Arroyo Boulevard Covered Floodways and channels. As described previously, the Nogales Wash Covered Floodway begins approximately 1 mile south of the International Boundary in Nogales, Sonora, Mexico and terminates in Nogales, Arizona a short distance upstream from the confluence of Nogales Wash and the Arroyo Boulevard channels. The Arroyo Boulevard Covered Floodway also originates in Mexico and outlets beneath the public library in Nogales, Arizona. From the outlets of the covered floodways, floodwaters from the Nogales Wash drainage are conveyed through the city in open, concrete-lined channels. The covered floodways will provide protection from approximately the 50-year frequency flood, and the capacity of the open, concrete-lined channels exceeds the 100-year discharge.

The effectiveness of the enlarged channel on Nogales Wash is reduced by the limited capacity of the bridge located at mile station 4.048. It has been estimated that floods exceeding the 50-year discharge will impinge on the bottom of the bridge, causing water to flow out of the channel and onto the east flood plain. Should the bridge opening be enlarged, the channel immediately downstream of the bridge has sufficient capacity to carry a discharge exceeding the 100-year flood magnitude.

The levees constructed on Mariposa Canyon to protect the new shopping center provide protection for approximately the 50-year frequency flood. The levee system on Mariposa Canyon in the vicinity of the western corporate limits offers protection approaching the 100-year discharge, but it was judged that this flood would overtop and breach the levee system. Should this happen, the gravel pit located in this area would store a limited amount of flood overflow.

The only other major flood protection measures located in the city are on Ephriam Canyon Wash. The Ephriam Canyon channel was enlarged in the early 1930s to provide flood protection for an army camp located in the flood plain of the streams at that time. There has also been a covered floodway (or culvert) installed on the lower end of Ephriam Canyon Wash to convey floodwaters from the west side of Bayze Avenue to near the confluence of the Ephriam Canyon Channel with Nogales Wash. Both of these measures offer protection from approximately a 10- to 20-year frequency flood.

Figure 2. Estimated 100- and 500-Year Flood Depths in Common Flood Plain Area of Nogales Wash and Potrero Creek Channel or Overtopping of Nogales Wash Flows Over U.S. Highway 89 or Old Tucson Highway

Figure 3. Looking West Across Morley Avenue in Front of Post Office at Huggins Street (Showing Shallow Sheet Flooding)

Figure 4. Looking Southeast Toward the International Border Station at Entrance to Nogales, Sonora, Mexico

Figure 5. Looking Northeast at Front Entrance to Civic Building in Nogales, Arizona

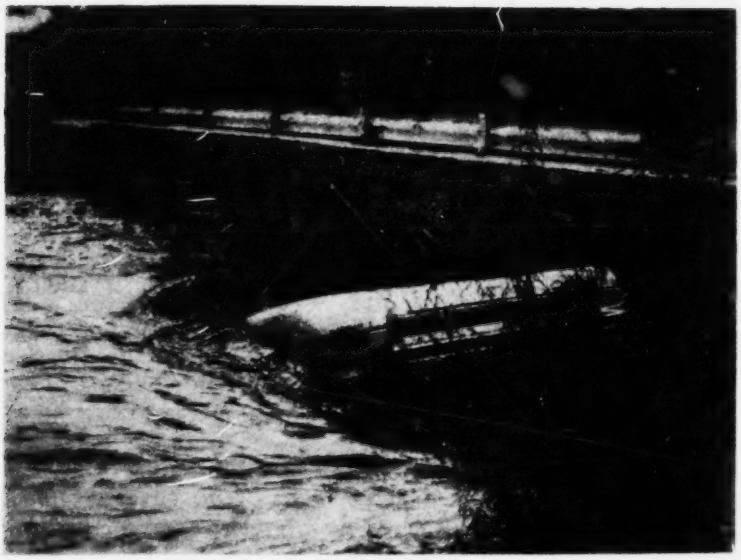

Figure 6. July 3, 1975 Flood on Ephriam Canyon at Western Avenue Bridge, Located Just Downstream of Interstate Highway 19

Figure 7. Estimated 100- and 500-Year Flood Depths at the Northwest Corner of the A. J. Mitchell Elementary School Building (Located on Ephriam Canyon at Corner of Western Avenue and Jesus E. Bautista Street)

Figure 8. Looking Upstream along Falls Wash Channel from Morley Avenue Bridge

Figure 9. Looking Downstream Along Falls Wash From Morley Avenue Bridge

Other short reaches of flood control channels are located on the State Highway 82 Tributary and Covered Floodway and on the lower end of Falls Wash downstream of State Highway 82. Because of the formation of a hydraulic jump on Falls Wash at the outlet end of the State Highway 82 culvert, the flood protection offered by the improved channel at this location is limited. It was estimated that approximately a 25- to 30-year flood would overtop the channel in this area. The open channel on the State Highway 82 Tributary has the capacity to carry approximately the 100-year flood, but its effectiveness is somewhat limited because of poor inlet conditions into the channel.

A series of corrugated metal pipe-arch and concrete box structures located on the west side of Arroyo Boulevard between Walnut and Quarry Streets offer some flood protection for this area. These structures will generally handle the discharge from local runoff for the 100-year flood, but the area would be subject to inundation from any flood exceeding the 50-year discharge from the Nogales Wash drainage area.

Another small flood control project consists of a levee system located downstream from the mouth of Smugglers Canyon. This levee system was constructed to protect the Lincoln Elementary School and local residences located in this area. The levee system, however, does not tie into the hill at the mouth of the canyon, and floodwaters can overtop the channel at this point. Also, proceeding downstream from the point where the channel turns west to join Nogales Wash, there is a decrease in channel capacity caused by sediment buildup. Floodwaters can therefore overtop the levees here and inundate the adjacent flood plains. The depth of flooding, however, will be shallow, usually less than 1 foot.

Current flood plain management measures taken to reduce flood potential consist of inspection by the City Building Inspector and City Engineer of subdivisions and private residential developments to ensure that building sites are reasonably safe from flooding. If a proposed building site is in a location that has a flood hazard, any proposed new construction or substantial improvement (including prefabricated and mobile homes) must: "(1) be designed (or modified) and anchored to prevent flotation, collapse, or lateral movement of the structure; (2) use construction materials and utility equipment that are resistant to flood damage; and (3) use construction methods and practices that will minimize flood damage" (Reference 5). The City Building Inspector and City Engineer also review subdivision proposals and other proposed new developments to assure that adequate drainage is provided to reduce exposure to flood hazards.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the community.

Streamflow data used in this study were taken from eleven crest-stage gaging stations and two continuous gaging stations analyzed by the U.S. Geological Survey, and six continuous-record gaging stations analyzed by the U.S. Soil Conservation Service and the U.S. Army Corps of Engineers. The crest-stage stations, located in the Nogales-Tucson area, measured runoff from drainage areas varying from 0.15 to 38.4 square miles, and had a length of record from 6 to 14 years. The continuous-record stations measured runoff from drainage areas varying from 35.5 to 2222 square miles, and had periods of record from 21 to 57 years.

Rainfall-runoff methods were used to analyze runoff from selected watersheds as a check against the transposed gaged data. The basic procedures used are described in the U.S. Soil Conservation Service engineering handbook (Reference 6) and other related technical notes.

Studies that have been made for the Upper Santa Cruz River area that would be applicable to the City of Nogales include: (1) those made by the U.S. Soil Conservation Service as part of the Flood Insurance Studies for the unincorporated areas of Santa Cruz County (Reference 1); (2) Flood Information reports made by the U.S. Army Corps of

Engineers (References 7-10); and (3) the method of determining peak discharge-frequency relationships as described in U.S. Geological Survey publications (References 11 and 12).

All of these studies were based upon statistical analyses of stream-flow data and employed various methods of transposing the study results for estimating peak discharge-frequency relationships for ungaged stream locations.

The results of these studies vary significantly. This required coordination meetings to resolve differences and to reach agreement on acceptable regional relationships.

In certain locations within the city, the peak discharges derived from the regional studies were modified because of the effect of hydraulic structures or other unique conditions which altered the peak rates of runoff. The only streams affected in this manner are Ephriam Canyon Wash and the flood plain area located west of Arroyo Boulevard between Walnut and Quarry Streets.

The flows on Ephriam Canyon Wash are affected by two high roadfills and their associated culverts which tend to reduce the peak discharge flow rates below these structures. The roadfills are located on State Highway 189 and Interstate Highway 19. The peak discharges for Ephriam Canyon Wash below these roadfills were determined by flood routing the flows through the two roadways, taking into account the effect of storage behind the structures.

The peak discharges for the flood plain area located west of Arroyo Boulevard between Walnut and Quarry Streets were derived from local runoff for the 10- and 50-year floods but are controlled by overland flow discharges overtopping the Arroyo Boulevard from Nogales Wash for the 100- and 500-year floods.

Peak discharge-drainage area relationships for Potrero Creek, Nogales Wash, Nogales Wash and/or Arroyo Boulevard Channel, Mariposa Canyon, Mariposa Canyon Tributaries No. 1 and No. 2, Ephriam Canyon Wash, Falls Wash, the flood plain area lying west of Arroyo Boulevard between Walnut and Quarry Streets, and the International Boundary Channel are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Cross sections for streams studied in detail were obtained from strip topographic maps at a scale of 1:2400, with a contour interval

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Potrero Creek					
At U.S. Highway 89 Bridge (North of Corporate Limits)	14.4	1,980	5,040	7,000	16,800
At Western Corporate Limits	11.3	1,700	4,390	6,100	14,640
Nogales Wash					
Near Nogales City Limits	61.0	4,600	11,300	15,700	37,680
At Southern Pacific Railroad Bridge	58.4	4,540	11,160	15,500	37,200
Downstream From Confluence With Mariposa Canyon (Cross Section T)	56.5	4,510	11,090	15,400	36,960
At 4.083 Miles Above Mouth (Old Corporate Limits)	40.9	3,760	9,580	13,300	31,920
Downstream of Confluence with Ephriam Canyon Wash at Cross Section AR	35.8	3,450	8,780	12,200	29,280
Downstream of Nogales Wash and Arroyo Boulevard Channel Confluence (Cross Section AX)	27.4	2,940	7,500	10,400	24,960
Nogales Wash and/or Arroyo Boulevard Channel					
Upstream of Confluence With Nogales Wash (Cross Section AY[1])	27.4[2]	2,940	7,500	10,400	24,960[3]
Nogales Wash		2,350	6,000	6,000	12,400
Arroyo Boulevard Channel		590	1,500	4,400	12,560
At International Boundary	26.3[4]	2,940	7,500	10,400	24,960
Nogales Wash Covered Floodway		2,350	6,000	6,000	6,000
Overland Flow East of Southern Pacific Railroad	--	200[5]	500[5]	1,200	7,100
Arroyo Boulevard Covered Floodway	--	590	1,500	1,600	2,060
Overland Flow West of Southern Pacific Railroad	--	360[5]	780[5]	1,600	9,800

Engineers (References 7-10); and (3) the method of determining peak discharge-frequency relationships as described in U.S. Geological Survey publications (References 11 and 12).

All of these studies were based upon statistical analyses of stream-flow data and employed various methods of transposing the study results for estimating peak discharge-frequency relationships for ungaged stream locations.

The results of these studies vary significantly. This required coordination meetings to resolve differences and to reach agreement on acceptable regional relationships.

In certain locations within the city, the peak discharges derived from the regional studies were modified because of the effect of hydraulic structures or other unique conditions which altered the peak rates of runoff. The only streams affected in this manner are Ephriam Canyon Wash and the flood plain area located west of Arroyo Boulevard between Walnut and Quarry Streets.

The flows on Ephriam Canyon Wash are affected by two high roadfills and their associated culverts which tend to reduce the peak discharge flow rates below these structures. The roadfills are located on State Highway 189 and Interstate Highway 19. The peak discharges for Ephriam Canyon Wash below these roadfills were determined by flood routing the flows through the two roadways, taking into account the effect of storage behind the structures.

The peak discharges for the flood plain area located west of Arroyo Boulevard between Walnut and Quarry Streets were derived from local runoff for the 10- and 50-year floods but are controlled by overland flow discharges overtopping the Arroyo Boulevard from Nogales Wash for the 100- and 500-year floods.

Peak discharge-drainage area relationships for Potrero Creek, Nogales Wash, Nogales Wash and/or Arroyo Boulevard Channel, Mariposa Canyon, Mariposa Canyon Tributaries No. 1 and No. 2, Ephriam Canyon Wash, Falls Wash, the flood plain area lying west of Arroyo Boulevard between Walnut and Quarry Streets, and the International Boundary Channel are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Cross sections for streams studied in detail were obtained from strip topographic maps at a scale of 1:2400, with a contour interval

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Nogales Wash					
Near Nogales City Limits	61.0	4,600	11,300	15,700	37,680
At Southern Pacific Railroad Bridge	58.4	4,540	11,160	15,500	37,200
Downstream From Confluence With Mariposa Canyon (Cross Section T)	56.5	4,510	11,090	15,400	36,960
At 4.083 Miles Above Mouth (Old Corporate Limits)	40.9	3,760	9,580	13,300	31,920
Downstream of Confluence with Ephriam Canyon Wash at Cross Section AR	35.8	3,450	8,780	12,200	29,280
Downstream of Nogales Wash and Arroyo Boulevard Channel Confluence (Cross Section AX)	27.4	2,940	7,500	10,400	24,960
Nogales Wash and/or Arroyo Boulevard Channel					
Upstream of Confluence With Nogales Wash (Cross Section AY[1])	27.4[2]	2,940	7,500	10,400	24,960[3]
Nogales Wash		2,350	6,000	6,000	12,400
Arroyo Boulevard Channel		590	1,500	4,400	12,560
At International Boundary	26.3[4]	2,940	7,500	10,400	24,960
Nogales Wash Covered Floodway		2,350	6,000	6,000	6,000
Overland Flow East of Southern Pacific Railroad	--	200[5]	500[5]	1,200	7,100
Arroyo Boulevard Covered Floodway	--	590	1,500	1,600	2,060
Overland Flow West of Southern Pacific Railroad	--	360[5]	780[5]	1,600	9,800

Table 1. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Mariposa Canyon					
At Confluence With Nogales Wash	12.5	1,840	4,680	6,500	15,600
At Interstate Highway 19	12.0	1,780	4,540	6,300	15,120
At Western Corporate Limits	9.1	1,470	3,740	5,200	12,480
Mariposa Canyon Tributary No. 1					
At Confluence With Mariposa Canyon (Cross Section A)	0.4	200	520	720	1,730
Mariposa Canyon Tributary No. 2					
At Confluence With Mariposa Canyon	0.4	220	550	760	1,820
Ephriam Canyon Wash					
At Entrance to Ephriam Canyon Covered Floodway (Bayze Avenue)	7.6	1,320	2,600	3,330	6,880
Downstream of Interstate Highway 19	6.6	1,200	2,600	3,330	6,880
Upstream of Interstate Highway 19 (Cross Section Z)	6.5	1,190	2,600	3,380	7,540
At Station 2.621 Miles Above Mouth (Old Corporate Limits)	6.0	1,130	2,600[6]	3,380[6]	7,540[6]
Downstream of State Highway 189 (Cross Section AE)	6.0	1,130	2,600[6]	3,380[6]	7,540[6]
At International Boundary	5.8	1,130	2,880	4,000	9,600

Table 1. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Falls Wash					
At Upstream Limit of Detailed Study (Old Corporate Limits)	4.4	930	2,380	3,300	7,920
Flood Plain Area West of Arroyo Boulevard Between Quarry and Walnut Streets at Cross Section BE	0.2	--[7]	80[7]	670[8]	5,400[8]
International Boundary Channel					
At Cross Section C	1.7	570	1,300	1,800	4,150

[1]Note: Both the total discharge and the division of flow as used in calculating the flood profiles have been shown for Nogales Wash and/or Arroyo Boulevard Channel at cross section AY and the International Boundary.

[2]Represents total drainage area for flows in Nogales Wash and Arroyo Boulevard Channel.

[3]Total flow east of Southern Pacific Railroad at cross section AY and includes 6000 cfs in Nogales Wash Channel and 6400 cfs estimated to be flowing in east flood plain.

[4]Represents total drainage area for flows in Nogales Wash Covered Floodway, overland flows east and west of Southern Pacific Railroad, and Arroyo Boulevard Covered Floodway.

[5]Overland flow discharges for 10- and 50-year floods were based on local runoff originating downstream of covered floodway entrances, and were assumed not to add to nor subtract from peak discharge for total drainage area.

[6]Discharges on Ephriam Canyon Wash reduced due to effect of high roadfill on State Highway 189.

[7]The 10-year and most of the 50-year peak discharge, based on local runoff, is controlled by box culverts located on each side of Plum Street upstream of cross section AY.

[8]Discharges for the 100- and 500-year floods are the result of overland flows from Nogales Wash drainage which overtop Arroyo Boulevard from the east.

of 2 feet, developed by photogrammetric methods (Reference 13). All bridge and culvert data not available from other sources were obtained by field surveys. Data on selected street and highway bridges and on the Arroyo Boulevard Covered Floodway were obtained from the Arizona Highway Department. Data on the Nogales Wash Covered Floodway were obtained from the International Boundary and Water Commission (References 14 and 15). Typical channel cross sections on the Nogales Wash concrete-lined channel and on the International Boundary Channel were measured in the field. Sample cross sections on Elm, Walnut, West, and Bowman Streets were also obtained by field measurements.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 3). Cross sections C and K on Nogales Wash show representative views of the channel configuration (Exhibit 2).

Water-surface profiles were computed using the U.S. Soil Conservation Service WSP-2 computer step-backwater model, where applicable (Reference 16). These computations were supplemented by step-backwater computations made using an office programmable calculator, and by manual computations made for supercritical flow reaches.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

Flows on Nogales Wash were analyzed in two separate reaches. The first reach extends from the International Boundary downstream to the confluence of Nogales Wash and the Arroyo Boulevard channels. The second reach consists of the remaining length of Nogales Wash which lies within the city. Flood profiles calculated for the upstream reach were complicated in that floodwaters can take any of 4 possible flow paths. These include two covered floodways and two overland flow routes. Although the two covered floodways have highway and street inlets along their courses, these have limited capacities and, thus, were ignored in calculating the flood profiles.

Because flows in this reach are in the supercritical range, a separation of flows was made at the International Boundary and flood profiles were calculated downstream along each of the flow paths.

Overland flows downstream of Court Street can overtop Arroyo Boulevard and flow along its west side and enter a series of culverts located in this area between Walnut and Quarry Streets. The flows entering the culverts are discharged into the Arroyo Boulevard Covered Floodway. Appropriate adjustments were made in the affected flood profiles for this reach and in the affected reaches downstream.

The first road and bridge section encountered when computing the profiles in a downstream direction is the Southern Pacific Railroad bridge located at the outlet end of the Arroyo Boulevard Channel. Flows at this location were analyzed manually and consist of flows along Grand Avenue, flows through the railroad bridge, and weir flow across the top of the railroad. Rating curves were developed separately for each of these flow conditions and then combined graphically to obtain the total flow capacity for the section.

There is, however, a possibility of a hydraulic jump occurring in the vicinity of the Southern Pacific Railroad bridge for floods less than the 100-year frequency. The jump is a result of backwaters from Nogales Wash. Due to the widening of the channel under the bridge, flood elevations for the 50- and 100-year floods on the Arroyo Boulevard Channel are below those calculated for these same frequencies on Nogales Wash. Based on the analysis, it was determined that the jump would probably occur downstream of cross section AY. However, since the reach involved is short and there is some uncertainty as to the exact location of the jump, it was decided that in plotting the flood profiles, the jump would not be shown; but the computed elevations at cross section AY would be joined directly with those on Nogales Wash at the confluence of the two streams (Exhibit 1).

For the reach downstream of the Nogales Wash-Arroyo Boulevard Channel confluence, all flows equal to or less than the 100-year flood are confined to the concrete-lined channel. These flows are again supercritical and were calculated manually, using the step procedure. The 500-year flood, however, will overtop the channel walls and cause flooding in the overflow areas. Profile elevations for this flood were determined from a combined rating curve developed for each cross section, based on supercritical flow within the channel and subcritical flow outside the channel.

There are two locations in this reach where the flood profiles are affected by bridge crossings. These are on Banks Bridge, located just downstream of the Nogales Wash-Arroyo Boulevard Channel confluence, and on a second bridge located at River Mile 4.048.

The Banks Bridge is a clear span bridge, and all flows equal to or less than the 100-year flood will pass beneath the bridge with little or no head loss. On the 500-year flood, however, flow will impinge upon the bottom of the bridge, and discharge through the bridge will be controlled by orifice flow. Because the flow in this area is supercritical except for the effect of the bridge, it was assumed a hydraulic jump would occur upstream of the bridge and force water out into the east and west flood plains. Flow on the west side of the bridge is confined by the Southern Pacific Railroad,

and continues downstream to approximately 300 feet upstream of the Nogales Wash - Ephriam Canyon Wash confluence.

Flow at the bridge located at River Mile 4.048 is even more complex than that described for the Banks Bridge. At this location, the exact nature of flood profiles exceeding the 50-year discharge is unknown due to the complex flow conditions encountered at this location. The channel in the reach is concrete-lined and due to existing slopes, flow would be in the supercritical range except for the effect of the bridge structure. The bridge opening is smaller than the channel over which it crosses, and, thus, tends to constrict the flow. A further complication of the flood profiles in the reach is the result of an expansion and contraction of the channel with a concurrent change in the channel bottom grade at a location just upstream of the bridge. This latter condition is a result of the concrete-lined channel being terminated at this point and then being extended further downstream at a later date. It was assumed in the profile analysis that once the top of the bridge was encountered, orifice flow would result and a hydraulic jump would be formed upstream of the bridge. This flow will force water out of the channel onto the adjacent flood plain.

The profiles for Nogales Wash - Flow west of U.S. Highway 89 and Southern Pacific Railroad reflect only these flows which spill over from the main channel once the channel capacity has been reached.

In the upper reaches of Mariposa Canyon, a basic assumption in the analysis was the size and location of a breach in the levee system located in the vicinity of the western corporate limits. It was assumed that a 50-foot breach would occur in the channel levee just upstream of the corporate limits. This assumption was based on the physical condition of the levee system at the time of the study. A division of flow was made and separate flood profiles were calculated for the channel and for the valley (north flood plain). Since the 50-year flood does not breach the levee system, the division of the 100-year flood causes the 50-year channel flow to exceed that of the 100-year channel flow. The elevation of the 50-year profile for the channel is, thus, higher than that for the 100-year profile for the portion of the reach affected by the levee system.

Because only the 100-year and 500-year events will breach the levee, only those recurrence intervals are presented on the profiles for Mariposa Canyon (Valley).

The flood profiles on Ephriam Canyon Wash are based on rating curves developed using the WSP-2 computer program (Reference 16), except on reaches where supercritical flows were encountered. There, the flood profiles were calculated by procedures as described earlier for this type of flow. At the outlet end of Ephriam Canyon, flows in the covered floodway are controlled by entrance conditions. Once the capacity of the floodway is exceeded, the overland discharge can take either one of two possible paths: Either east along the top of the covered floodway to confluence with Nogales Wash at the outlet end of the covered floodway; or north-northeast along Grand Avenue

between the Time and Eldorado Motels to join Nogales Wash near the State Highway 82 overpass.

The office programmable calculator was used to estimate the flood depths on the State Highway 82 Tributary, on Falls Wash upstream of State Highway 82, and on the two small unnamed tributaries located east of Nogales Wash opposite Ephriam Canyon. Except for Falls Wash, however, flood profiles were not developed for these streams because their drainage areas are small, and the estimated flood depths are generally less than 1 foot for the 100-year flood. On Falls Wash downstream of State Highway 82, flood elevations were based on manual calculations.

The programmable calculator was also used to compute the flood elevations for the low-lying areas west of Arroyo Boulevard between Walnut and Quarry Streets along a profile baseline.

Roughness coefficients (Manning's "n") were estimated by field inspection at each cross section. The U.S. Soil Conservation Service's National Engineering Handbook, Supplement B (Reference 17) was used as a guide in selecting the roughness coefficients. Where applicable, Manning's "n" values used by the International Boundary and Water Commission in the design of the flood control channels in the city, were used in this study. Roughness values for the main channels ranged from 0.014 for the covered floodways to 0.045 for the natural channels. The average value used for the natural channels was 0.035.

Most of the flood plains in the city are occupied by commercial and residential buildings, with only limited open areas available for floodflows. Most of the flows in the flood plains are confined to streets and roadways paralleling the direction of flow. Manning's "n" values for the roadways and adjacent open areas varied from 0.015 to 0.020. For some cross sections, high "n" values (0.200 to 0.999) were used to represent areas partially or totally blocked by houses and other buildings.

Starting water-surface elevations for profiles computed using the WSP-2 computer step-backwater model (Reference 16) on Potrero Creek, Mariposa Canyon and Mariposa Canyon Tributaries No. 1 and No. 2, and portions of Nogales Wash were estimated using the flood elevation of the corresponding recurrence intervals from their parent stream. Starting water-surface elevations for the upstream reaches of Ephriam Canyon Wash and the International Boundary Channel were determined from the stage-discharge relationship developed from a culvert rating of their covered floodways.

A critical depth was determined at the International Border for application to all flooding sources with supercritical flows. A control cross section is located at International Street where flow from the International Boundary Covered Floodway overtops the Southern Pacific Railroad enbankment and is conveyed to the Nogales Wash and Arroyo Boulevard Covered Floodways and overland flows. The super-critical flow situation then exists along these drainages to a point at the downstream end of the Nogales Wash concrete-lined channel at approximately River Mile 3.79.

Flood elevations on Elm, Walnut, West, and Bowman Streets were based on approximate methods. These consisted of using the slope of the streets for the slope of the energy grade line in Manning's Formula and calculating normal depths. Similar procedures were used for other small unnamed tributaries analyzed by approximate methods.

Elevations and depths for shallow flooding areas were determined using an office programmable calculator based on representative downstream cross sections. The resulting data was then applied to local topographic conditions.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

There are, however, in certain locations within the city, bench marks stamped with the Nogales Datum. This datum was found to be approximately 12.6 feet below the NGVD. Although none of the Nogales Datum bench marks were used in this study, caution should be used, should this datum be encountered, in trying to determine base flood elevations for flood insurance purposes.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage State and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Insurance Administration as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2400, with a contour interval of 2 feet (Reference 13).

In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown.

The actual limits of the overflow areas on the ground may vary somewhat from those shown on the maps because the scale of the maps does not permit precise plotting of the flooded area boundaries. This is especially true along Nogales Wash and the Arroyo Boulevard channels downstream of the covered floodway outlets. On these two streams, the 100-year flood is confined to the channel by parapet walls located along each side of the channel. Due to the scale of the

map, the width of the 100-year flood plain for these reaches may be exaggerated over actual flood boundary limits.

Flood boundaries determined by approximate methods were delineated based on the topographic maps (Reference 13) and the average flood depths estimated for each of the streams.

Flood boundaries for the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2).

Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management: Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment in order that the 100-year flood be carried without substantial increases in flood heights. As minimum standards, the Federal Insurance Administration limits such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced.

Floodways generally are not appropriate for most streams located within the older, established parts of Nogales because most of their flood plains are already fully developed. Only in the upper reaches of Ephriam Canyon Wash, from approximately 280 feet downstream of cross section J upstream to the International boundary, is a floodway recommended.

The two existing covered floodways located in the upper reaches of the Nogales Wash flood plain, however, will convey any flood equal to or less than the 50-year flood, downstream of the covered floodways, the 100-year discharge is confined to the open, concrete-lined channels.

On Nogales Wash downstream of Monte Carlo Road a floodway was not computed due to the unique flooding conditions caused by the embankemnts of the Southern Pacific Railroad, U.S. Highway 89, and the old Tucson Highway. However, it is essential that sound flood plain management be practicied by the City of Nogales in this area to insure that the existing flood hazard is not aggravated. No cross sections are shown in this reach on the FBFM (Exhibit 3), but they are presented on the Flood Profiles (Exhibit 1).

Upstream of Monte Carlo Road to the old Nogales Waste Water Treatment Plant, the floodway is based on equal conveyance loss on each side of the channel. At selected cross sections, however, slight modifications were made to give a more uniform alignment or for better transition of the floodway between cross sections.

The Nogales Wash floodway along the west side of the old Waste Water Treatment Plant and upstream to the developed part of Nogales is basically confined to the stream channel. However, to ensure its proper functioning, the bridge across the channel at River Mile 4.048 needs to be enlarged or removed to eliminate the constriction which presently exists at this location. The bridge constriction causes perched flood flows in the east flood plain, and these flows were used in the computation of the natural elevations. Floodway elevations for cross sections in this reach were computed without consideration of the bridge effect, thus assuming the flows to be confined to the channel. Therefore, floodway elevations for cross sections AF through AK, as shown in the Floodway Data Table (Table 2), are lower than the corresponding natural elevations. In the reach where the floodway velocities approach 30 feet per second, the stream channel is presently concrete lined.

The floodway on Mariposa Canyon between U.S. Highway 89 and Interstate Highway 19 is essentially confined to the stream channel. The computed floodway follows fairly close to an existing levee system constructed to protect the shopping center located in this area. Extreme caution, however, should be exercised in this reach should further development be allowed in the flood plain, since velocities in the computed floodway exceed 10 feet per second at most cross sections. Consideration should be given to providing protection for both the channel bottom and stream banks.

In the reach on Mariposa Canyon between Interstate Highway 19 and the lower crossing of State Highway 189, it is recommended that a levee be constructed to prevent any overflow of the 100-year flood from passing through the Mariposa crossroad underpass on Interstate Highway 19. This assumption was made in developing the proposed floodway.

In the reach on Mariposa Canyon Tributary No. 2 from its confluence with Mariposa Canyon at State Highway 189 to its upstream crossing of a trailer park road, the computed floodway does not follow the channel as shown on the map because floodflows will proceed parallel to the south side of the road.

In the upper reaches of Mariposa Canyon near the western corporate limits, the existing levee system presently serves as a floodway for the more frequent floodflows. Although these levees will not control the 100-year flood, they are adequate for the present flood plain use; because the flood plain will be in a continuous state of change for the next few years, no further definition of a floodway for flood insurance purposes is recommended at this time.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION[1]			
CROSS SECTION	DISTANCE[2]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Potrero Creek								
A	4.929	716	4555	1.51	3647.6	3647.6	3648.6	1.0
B	4.938	716	1927	3.58	3647.7	3647.7	3647.9	0.2
C	4.972	429	1343	5.14	3649.4	3649.4	3650.4	1.0
D	4.996	194	848	8.14	3651.5	3651.5	3651.5	0.0
E	5.063	578	2839	2.43	3656.0	3656.0	3657.0	1.0
F	5.285	654	1367	4.90	3672.5	3672.5	3673.5	1.0
G	5.504	348	916	7.04	3687.0	3687.0	3688.0	1.0
H	5.712	293	758	8.25	3699.9	3699.9	3700.9	1.0
I	5.874	365	820	7.56	3709.8	3709.8	3710.8	1.0
J	6.049	165	555	11.18	3721.0	3721.0	3722.0	1.0
K	6.202	135	672	9.08	3730.8	3730.8	3731.8	1.0
L	6.273	200	751	8.13	3735.6	3735.6	3736.6	1.0
M	6.423	167[3]	650	9.23	3744.0	3744.0	3745.0	1.0
Nogales Wash								
W	3.003	488	2282	5.96	3745.5	3745.5	3746.5	1.0
X	3.100	279	1153	11.79	3747.9	3747.9	3748.9	1.0
Y	3.132	246	974	13.96	3749.0	3749.0	3749.5	0.5
Z	3.282	429	2295	5.88	3755.1	3755.1	3756.1	1.0
AA	3.370	385	1516	8.90	3757.8	3757.8	3758.8	1.0

[1]Water-Surface Elevations Computed Without Considering Effects of Debris or Scouring [2]Miles Above Mouth
[3]Width Lies Entirely Outside Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOODWAY DATA

POTRERO CREEK-NOGALES WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION[1]			
CROSS SECTION	DISTANCE[2]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Nogales Wash (Continued)								
AB	3.380	157	780	17.31	3760.0	3760.0	3760.0	0.0
AC	3.485	128	950	14.21	3764.5	3764.5	3764.5	0.0
AD	3.639	150	900	14.89	3770.7	3770.7	3770.7	0.0
AE	3.769	114	830	16.14	3776.1	3776.1	3776.1	0.0
AF	3.789	56	540	24.81	3779.2	3779.2[3]	3777.9	-1.3
AG	3.859	56	450	29.55	3780.1	3780.1[3]	3778.8	-1.3
AH	3.946	56	445	29.89	3783.7	3783.7[3]	3781.7	-2.0
AI	4.041	56	433	30.71	3787.8	3787.8[3]	3785.0	-2.8
AJ	4.062	56	455	29.23	3789.4	3789.4[3]	3786.4	-3.0
AK	4.072	56	465	28.60	3789.8	3789.8[3]	3787.3	-2.5
Mariposa Canyon								
C	0.083	125	665	9.77	3742.1	3742.1	3742.1	0.0
D	0.124	108	514	12.43	3742.4	3742.4	3743.1	0.7
E	0.174	118	627	10.19	3745.3	3745.3	3745.8	0.5
F	0.182	117	716	8.93	3746.9	3746.9	3746.9	0.0
G	0.382	125	541	11.81	3754.4	3754.4	3754.7	0.3
H	0.479	120	534	11.98	3759.5	3759.5	3759.5	0.0
I	0.489	120	534	11.97	3761.1	3761.1	3761.1	0.0
J	0.612	153	574	10.97	3768.9	3768.9	3768.9	0.0
K	0.619	153	573	10.97	3771.4	3771.4	3771.7	0.3
L	0.635	153	891	7.07	3772.1	3772.1	3773.1	1.0
M	0.772	120	523	12.02	3776.5	3776.5	3776.7	0.2
N	0.951	728	5962	1.04	3792.7	3792.7	3793.7	1.0
O	1.010	410	2155	2.88	3792.8	3792.8	3793.8	1.0

[1]Water-Surface Elevations Computed Without Considering Effects of Debris or Scouring
[2]Miles Above Mouth [3]Elevation for Perched Flow in East Flood Plain Resulting From a Bridge Constriction Upstream (See Section 4.2)

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOODWAY DATA

NOGALES WASH-MARIPOSA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION[1]			
CROSS SECTION	DISTANCE[2]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Mariposa Canyon (Continued)								
P	1.040	170	815	7.61	3792.9	3792.9	3793.9	1.0
Q	1.121	285	1578	3.93	3797.8	3797.8	3798.8	1.0
R	1.193	215	874	7.10	3801.2	3801.2	3802.2	1.0
S	1.299	315	981	6.32	3805.7	3805.7	3806.7	1.0
T	1.407	287	957	6.48	3812.4	3812.4	3813.4	1.0
U	1.424	291	856	7.24	3813.6	3813.6	3814.6	1.0
V	1.515	523	1066	5.63	3819.6	3819.6	3820.6	1.0
W	1.608	430	1050	5.71	3825.0	3825.0	3826.0	1.0
X	1.680	319	927	6.42	3828.4	3828.4	3829.4	1.0
Y	1.767	285	811	7.34	3832.9	3832.9	3833.4	0.5
Z	1.802	190	838	7.10	3833.7	3833.7	3834.2	0.5
AA	1.866	320	907	6.56	3838.7	3838.7	3839.2	0.5
AB	1.913	382	916	6.50	3842.7	3842.7	3843.7	1.0
AC	1.972	471	1086	5.48	3846.9	3846.9	3847.6	0.7
AD	2.053	471	1095	5.43	3853.5	3853.5	3854.5	1.0
AE	2.183	521	1316	4.52	3862.8	3862.8	3863.8	1.0
AF	2.409	324	1530	3.79	3880.9	3880.9	3880.9	0.0
AG	2.475	468	1309	4.43	3882.9	3882.9	3883.9	1.0
AH	2.591	543	1056	5.49	3890.8	3890.8	3891.8	1.0
AI	2.715	548	948	5.91	3902.8	3902.8	3903.8	1.0
AJ	2.938	270	686	7.80	3923.2	3923.2	3923.9	0.7

[1]Water-Surface Elevations Computed Without Considering Effects of Debris or Scouring
[2]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOODWAY DATA

MARIPOSA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION[1]			
CROSS SECTION	DISTANCE[2]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Mariposa Canyon Tributary No. 1								
A	0.153	101	278	2.59	3793.2	3793.2	3794.2	1.0
B	0.203	150	210	3.43	3797.3	3797.3	3798.3	1.0
C	0.291	166	171	4.21	3804.8	3804.8	3805.8	1.0
D	0.402	140	137	4.45	3815.6	3815.6	3816.6	1.0
E	0.472	146	138	4.41	3821.6	3821.6	3822.6	1.0
F	0.518	90	116	5.23	3825.9	3825.9	3826.0	0.1
G	0.642	118	202	3.02	3836.8	3836.8	3837.8	1.0
Mariposa Canyon Tributary No. 2								
A	0.287	85	138	5.50	3813.1	3813.1	3814.1	1.0
B	0.457	65	142	5.00	3826.4	3826.4	3827.4	1.0
C	0.610	64	90	6.87	3838.9	3838.9	3839.4	0.5

[1]Water-Surface Elevations Computed Without Considering Effects of Debris or Scouring [2]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOODWAY DATA

MARIPOSA CANYON TRIBUTARY NO. 1-MARIPOSA CANYON TRIBUTARY NO.2

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION[1]			
CROSS SECTION	DISTANCE[2]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Ephriam Canyon Wash								
J	0.800	65	356	9.37	3854.1	3854.1	3855.1	1.0
K	0.855	60	317	10.53	3856.7	3856.7	3857.7	1.0
L	0.899	36	249	13.37	3860.5	3860.5	3861.5	1.0
M	0.931	85	309	10.79	3862.5	3862.5	3863.5	1.0
N	0.982	86	389	8.58	3864.6	3864.6	3865.6	1.0
O	1.044	195	659	5.06	3867.8	3867.8	3868.3	0.5
P	1.106	115	464	7.18	3874.3	3874.3	3874.8	0.5
Q	1.143	82	406	8.20	3875.8	3875.8	3876.8	1.0
R	1.237	83	347	9.60	3881.8	3881.8	3882.8	1.0
S	1.340	114	427	7.81	3889.1	3889.1	3890.1	1.0
T	1.431	58	226	14.74	3895.0	3895.0	3896.0	1.0
U	1.517	168	380	8.77	3901.9	3901.9	3902.9	1.0
V	1.542	193	453	7.36	3904.2	3904.2	3905.2	1.0
W	1.625	45	269	12.38	3910.6	3910.6	3911.6	1.0
X	1.703	80	344	9.69	3913.0	3913.0	3914.0	0.5
Y	1.837	297	4019	0.83	3929.6	3929.6	3930.6	1.0
Z	2.066	115	411	8.22	3943.2	3943.2	3943.7	0.5
AA	2.256	228	347	9.73	3958.0	3958.0	3959.0	1.0
AB	2.465	60	297	11.36	3974.0	3974.0	3975.0	1.0
AC	2.546	95	303	11.15	3977.7	3977.7	3978.2	0.5
AD	2.608	225	1434	2.35	3979.1	3979.1	3979.6	0.5
AE	2.665	210	1222	2.76	3979.3	3979.3	3980.3	1.0
AF	2.750	198	2457	1.37	4003.0	4003.0	4004.0	1.0

[1]Water-Surface Elevations Computed Without Considering Effects of Debris or Scouring [2]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

FLOODWAY DATA

EPHRIAM CANYON WASH

Except as stated otherwise above, floodways were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 3), the floodway boundaries were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood boundaries are close together, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses that portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 10.

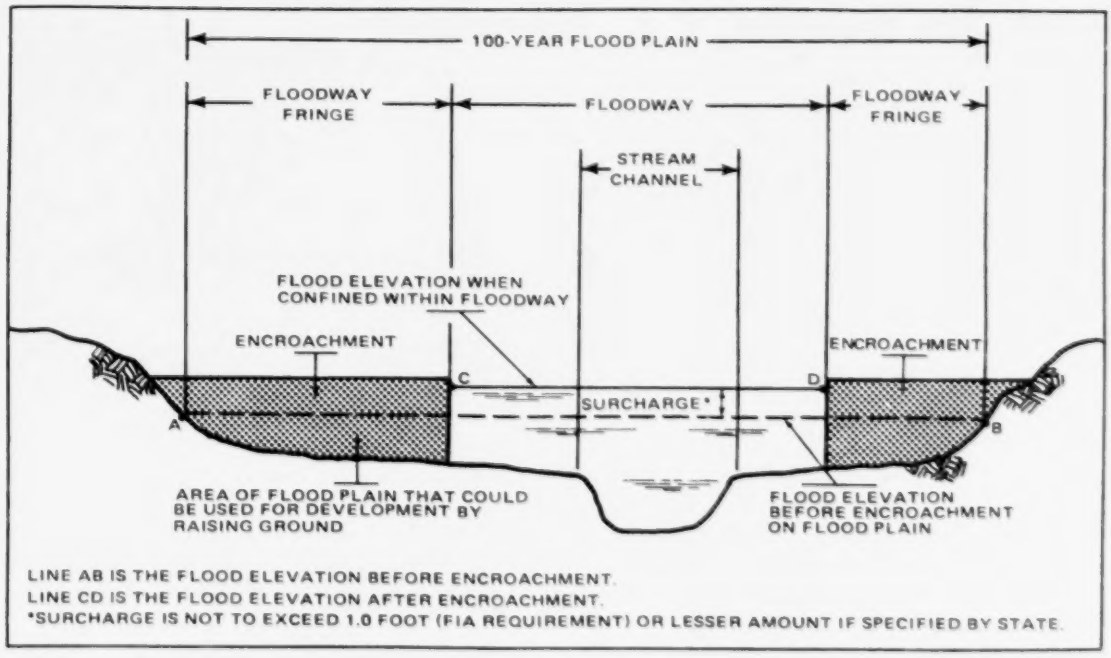

Figure 10. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Insurance Administration has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Nogales.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. In certain locations within the study area, however, the 10-year flood may be completely confined to the channel, whereas the 100-year flood exceeds the channel capacity. In these areas, reach lengths were determined based on the average weighted differences between the mean low flood plain elevations and the 100-year flood elevations. In all cases, the relative difference in elevations does not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the City of Nogales are shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

Locations in the city where mean low flood plain elevations were used in lieu of the 10-year flood elevations include the reaches on Arroyo Boulevard Channel, International Boundary Channel, Falls Wash, Reaches 2 and 6 on Nogales Wash and Reach 1 on Potrero Creek. The use of mean low flood plain elevations was limited to the flood plain north of the channel, Mariposa Canyon (Valley), in Reach 4 on Mariposa Canyon (Channel), and to the east of the channel (East Flood Plain) in Reach 4 and to flows west of U.S. Highway 89 and Southern Pacific Railroad on Nogales Wash. For the remainder of the designated reaches where the mean low flow plain elevations were used to determine the relative flood hazard, the total flood plain width was involved. On the Arroyo Boulevard Channel, mean low flood plain elevations were used only between Cardwell Street and LaCastellana Drive. For all other reaches within the study area, reach lengths were determined based on the average weighted difference between the 10- and 100-year flood elevations.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Potrero Creek							
Reach 1	0001,0004	-2.3[4]	-0.7	2.5	025	A5	Varies - See Map
Nogales Wash							
Reach 1	0001,0004	-6.0[4]	-1.0	1.6	060	A12	Varies - See Map
Reach 2	0004,0005	-3.5[4]	-0.5	1.6	035	A7	Varies - See Map
Reach 3	0005	-1.9	-0.6	2.1	020	A4	Varies - See Map
Reach 4 (Channel)	0005,0008	-5.2	-1.5	3.1	050	A10	Varies - See Map
(East Flood Plain)	0008	-2.2[4]	N/A	3.1	020	A4	Varies - See Map
(West Flood Plain)	0008	-1.7	-0.6	3.3	015	A3	3793
Reach 5	0008	-8.3[4]	-2.0	4.8	085	A17	Varies - See Map
Reach 6	0007,0008	-0.9[4]	-0.6	3.2	010	A2	Varies - See Map
Nogales Wash (Flow West of U.S. Highway 89 and Southern Pacific Railroad)							
Reach 1	0001,0004 0005	-2.5[4]	-1.0	2.7	025	A5	Varies - See Map

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot [4] Average Difference Between Mean Low Flood Plain Elevations and Base Flood Elevations

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD INSURANCE ZONE DATA

POTRERO CREEK-NOGALES WASH-NOGALES WASH (FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD)

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Arroyo Boulevard Channel and Covered Floodway and Overland Flows West of Southern Pacific Railroad							
Reach 1	0007,0008	-1.2	-1.1	3.0	010	A2	Varies - See Map
Mariposa Canyon (Channel)							
Reach 1	0004,0005	-3.2	-0.8	1.4	030	A6	Varies - See Map
Reach 2	0004	-5.9	-1.8	5.0	060	A12	Varies - See Map
Reach 3	0004,0007	-1.5	-0.4[4]	1.8	015	A3	Varies - See Map
Reach 4	0007	-1.0	0.5[4]	1.7	010	A2	Varies - See Map
Mariposa Canyon (Valley)							
Reach 1	0007	-1.1[5]	N/A	1.2	010	A2	Varies - See Map
Mariposa Canyon Tributary No. 1							
Reach 1	0004	-7.8	-2.3	6.4	080	A16	Varies - See Map
Reach 2	0004	-0.7	-0.2	1.0	005	A1	Varies - See Map
Mariposa Canyon Tributary No. 2							
Reach 1	0004	-0.8	-0.2	0.8	010	A2	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot [4]50-Year Elevation Exceeds 100-Year [5]Elevations Due to Breach in Levee System Resulting in a Division of Flow for the 100-Year Flood Average Difference between Mean Low Flood Plain Elevations and Base Flood Elevations

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES , AZ
(SANTA CRUZ CO.)

FLOOD INSURANCE ZONE DATA

ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD-MARIPOSA CANYON (CHANNEL)-MARIPOSA CANYON (VALLEY)-MARIPOSA CANYON TRIBUTARY NO. 1-MARIPOSA CANYON TRIBUTARY NO. 2

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Ephriam Canyon Wash							
Reach 1	0007,0008	-1.5	-0.4	1.2	015	A3	Varies - See Map
Reach 2	0007	-4.9	-1.8	8.2	050	A10	Varies - See Map
Reach 3	0007	-2.0	-0.6	1.9	020	A4	Varies - See Map
Reach 4	0007	-2.3	-0.7	1.5	025	A5	Varies - See Map
Reach 5	0007	-10.9	-5.5	17.0	110	A21	4003
Falls Wash							
Reach 1	0008	-0.9[4]	-1.3	2.6	010	A2	Varies - See Map
Flood Plain Area West of Arroyo Boulevard Between Quarry and Walnut Streets							
Reach 1	0008	-1.9	-1.2	2.1	020	A4	Varies - See Map
International Boundary Channel							
Reach 1	0007	-1.9[4]	-1.2	3.3	015	A4	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot
[4]Average Difference Between Mean Low Flood Plain Elevations and Base Flood Elevations

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD INSURANCE ZONE DATA

EPHRIAM CANYON WASH-FALLS WASH-FLOOD PLAIN AREA WEST OF ARROYO BOULEVARD BETWEEN QUARRY AND WALNUT STREETS-INTERNATIONAL BOUNDARY CHANNEL

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Shallow Flooding Area East of Nogales Wash Opposite Ephriam Canyon	0008	N/A	N/A	N/A	N/A	AH	3801
Shallow Flooding Area South of State Highway 82 Between Perkins Avenue and Falls Wash	0008	N/A	N/A	N/A	N/A	AO	Depth 1
Shallow Flooding Area Between Morley Avenue and Santa Cruz Street	0008	N/A	N/A	N/A	N/A	AH	3803

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD INSURANCE ZONE DATA

SHALLOW FLOODING AREA EAST OF NOGALES WASH OPPOSITE EPHRIAM CANYON · SHALLOW FLOODING AREA SOUTH OF STATE HIGHWAY 82 BETWEEN PERKINS AVENUE AND FALLS WASH CHANNEL · SHALLOW FLOODING AREA BETWEEN MORLEY AVENUE AND SANTA CRUZ STREET

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the Federal Insurance Administration device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200. The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations (and/or between mean low flood plain elevations and 100-year flood elevations as explained in Section 5.1) expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF os 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective Flood Hazard Factors, the entire incorporated area of the City of Nogales was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or Flood Hazard Factors determined.
Zone A0:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, but no Flood Hazard Factors are determined.
Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no Flood Hazard Factors are determined.
Zones A1-7, A10, A12, A16, A17, and A21	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

The flood elevation differences, Flood Hazard Factors, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Nogales is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Insurance Administration.

6.0 OTHER STUDIES

In October 1958, the U.S. Army Corps of Engineers completed a Reconnaissance Report on Ephriam Canyon Wash (Reference 10). The purpose of this report was to investigate the feasibility of installing a concrete-lined channel on the lower 0.875 mile of this wash for flood protection. The improved channel would be located within the corporate limits of the City of Nogales. The peak discharge-frequency relationships as developed by the U.S. Army Corps of Engineers for this report were in disagreement with those used by the U.S. Soil Conservation Service in this study. These disagreements have since been resolved, and the U.S. Army Corps of Engineers is currently using these Flood Insurance Study results to update their Reconnaissance Report.

Some disagreement also has occurred in the hydrologic and hydraulic analyses of Nogales Wash as used by the U.S. Soil Conservation Service in this Flood Insurance Study and those developed by the U.S. Army Corps of Engineers and International Boundary and Water Commission in conjunction with the installation of the Nogales Waste Water Treatment Plant, located just north of the southern corporate limits. The levee system installed

to provide flood protection for the waste treatment plant was designed for a 100-year peak discharge of 12,000 cubic feet per second (cfs). This value is in conflict with a peak discharge of 17,300 cfs being used by the U.S. Soil Conservation Service in this Flood Insurance Study. Letters of coordination were written to both the U.S. Army Corps of Engineers and the International Boundary and Water Commission concerning this matter. The International Boundary and Water Commission stated in their letter of reply dated November 17, 1976 that,

> Since the plant was designed and constructed on the basis of a thorough review by the U.S. Army Corps of Engineers and no flood events have occurred since 1970 to indicate a basis for a change, we do not believe it necessary to add further flood protection for the plant

A copy of the International Boundary and Water Commission letter was furnished to the U.S. Army Corps of Engineers and in their reply dated January 24, 1977, they stated,

> When the U.S. Soil Conservation Service began the Flood Insurance Study for Santa Cruz County, they performed a comprehensive hydrologic analysis for the county and noted the differences from our 1969 FPI (Flood Plain Information Report). The 1974 meeting ensued, and after evaluation of the two studies a compromise was reached. It is our feeling that the compromise value reflects a more complete data base and therefore more comprehensive evaluation than was available in 1969.

Because data are not available to more adequately define the 100-year peak discharge on Potrero Creek, and in order to be consistent with the hydrologic data used for the remainder of the study area, the peak discharges as agreed upon by the U.S. Soil Conservation Service, U.S. Army Corps of Engineers, and U.S. Geological Survey have been used on Potrero Creek for this Flood Insurance Study.

In the early 1930s, the International Boundary and Water Commission completed hydrologic and hydraulic analyses for the design and installation of the Nogales Wash and Arroyo Boulevard Channels and Covered Floodways. These complete data, however, were not available for use with this Flood Insurance Study. Data furnished by the International Boundary and Water Commission were used directly in this study. One of the major differences noted in the data furnished was in the estimated capacity of the Nogales Wash Covered Floodway. The design capacity as shown on plan and profile sheets for this floodway was 6500 cubic feet per second (cfs). The maximum capacity for the floodway as determined from this study was 6000 cfs. This difference is accounted for by the recent installation of a 30-inch sewer line pipe along the bottom on the east side of the covered floodway. The sewer line pipe is encased in a 4-foot by 4-foot concrete block. This has reduced the capacity of the floodway.

Another difference noted was in the elevation reference datum used in plotting the flood profiles. The International Boundary and Water Commission used the Nogales Datum which is approximately 12.6 feet lower than the NGVD used by the U.S. Soil Conservation Service in this study.

In addition to this study, the U.S. Soil Conservation Service has also performed Flood Insurance Studies for the unincorporated areas of Santa Cruz County, Arizona and for the Town of Patagonia, Arizona (References 1 and 2). Hydrologic data used for the Nogales study are compatible with those used in the other two studies. Flood profiles as calculated for the City of Nogales match those for the unincorporated areas of Santa Cruz County where these two studies join.

In 1979, the City of Nogales annexed more than 16 square miles of unincorporated Santa Cruz County. This took place after the Flood Insurance Studies for the city and county were complete in draft form, but before publication by the Federal Insurance Administration. Thus, much of the information originally developed for the Santa Cruz County study is presented in this study for the City of Nogales.

This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Insurance and Mitigation Division, Federal Emergency Management Agency, 450 Golden Gate Avenue, P.O. Box 36003, San Francisco, California 94102.

8.0 BIBLIOGRAPHY AND REFERENCES

1. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Santa Cruz County, Arizona (Unincorporated Areas), August 1980

2. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Town of Patagonia, Santa Cruz County, Arizona, March 1980

3. University of Arizona, Office of Arid Land Studies, Remote Sensing Project, "Review of Flood Hazard and Flood Plain Study for Nogales Wash," Tucson, Arizona, August 1979

4. Arizona Office of Economic Planning and Development, Nogales, Arizona Community Prospectus, July 1974

to provide flood protection for the waste treatment plant was designed for a 100-year peak discharge of 12,000 cubic feet per second (cfs). This value is in conflict with a peak discharge of 17,300 cfs being used by the U.S. Soil Conservation Service in this Flood Insurance Study. Letters of coordination were written to both the U.S. Army Corps of Engineers and the International Boundary and Water Commission concerning this matter. The International Boundary and Water Commission stated in their letter of reply dated November 17, 1976 that,

> Since the plant was designed and constructed on the basis of a thorough review by the U.S. Army Corps of Engineers and no flood events have occurred since 1970 to indicate a basis for a change, we do not believe it necessary to add further flood protection for the plant

A copy of the International Boundary and Water Commission letter was furnished to the U.S. Army Corps of Engineers and in their reply dated January 24, 1977, they stated,

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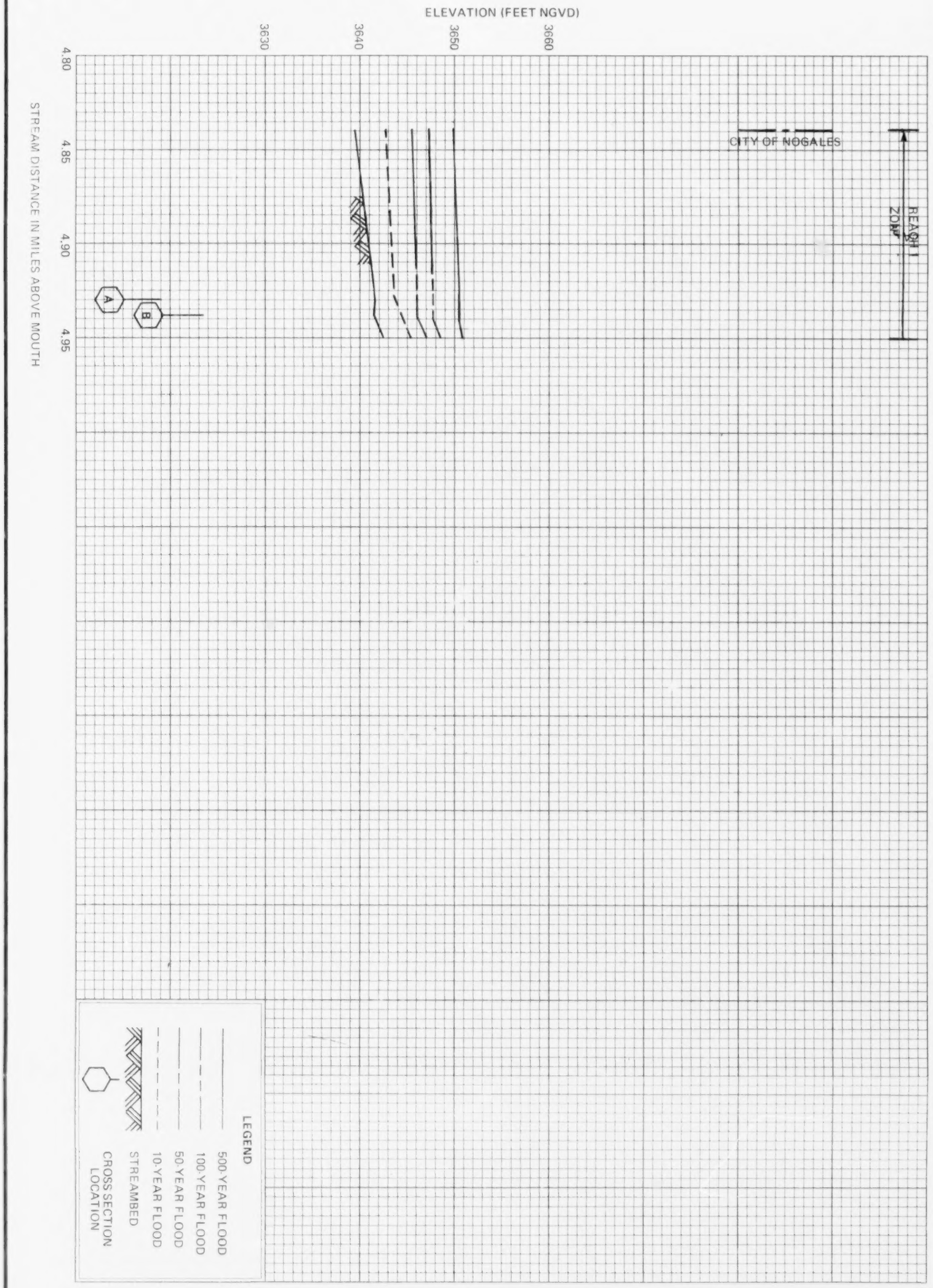

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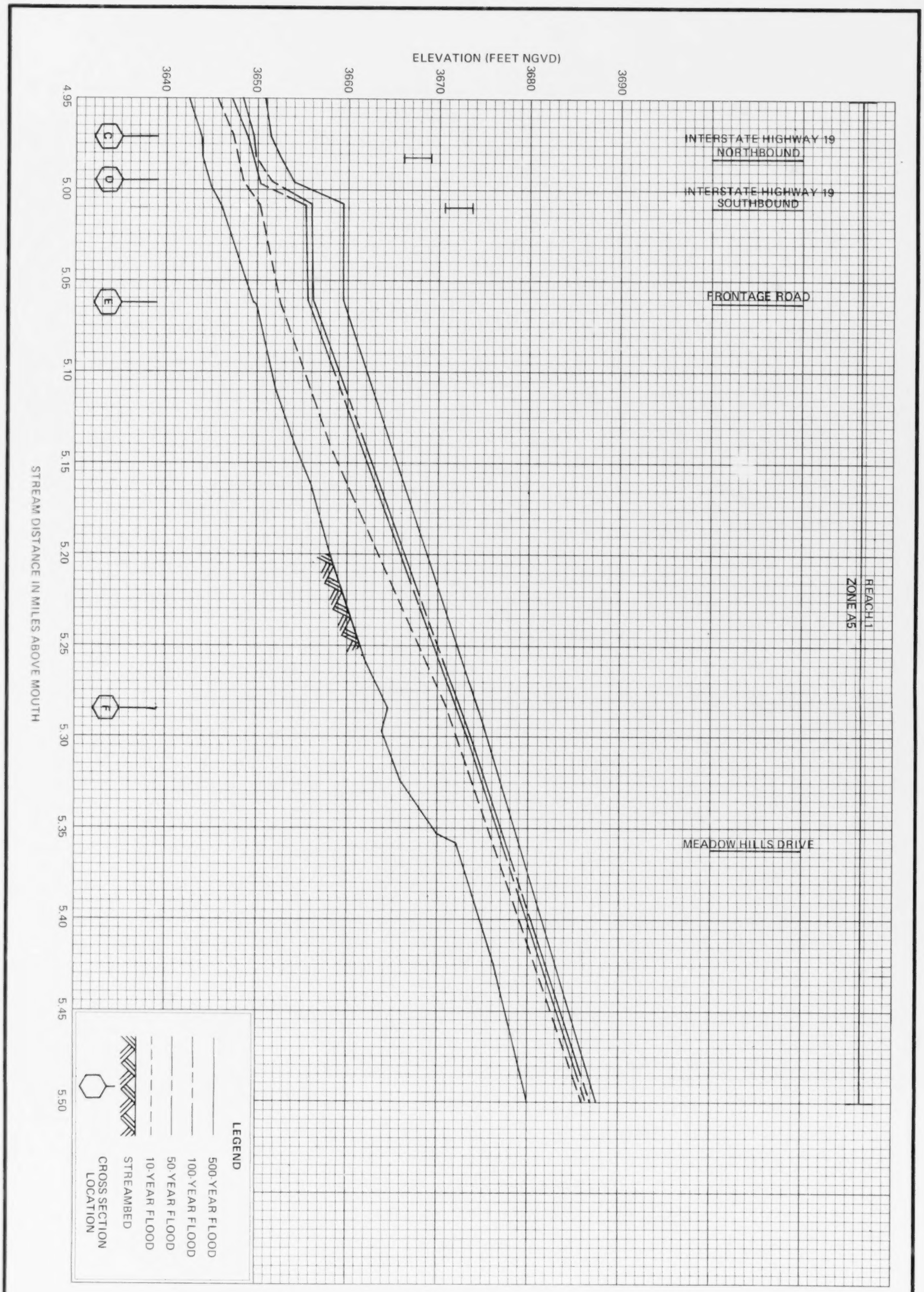


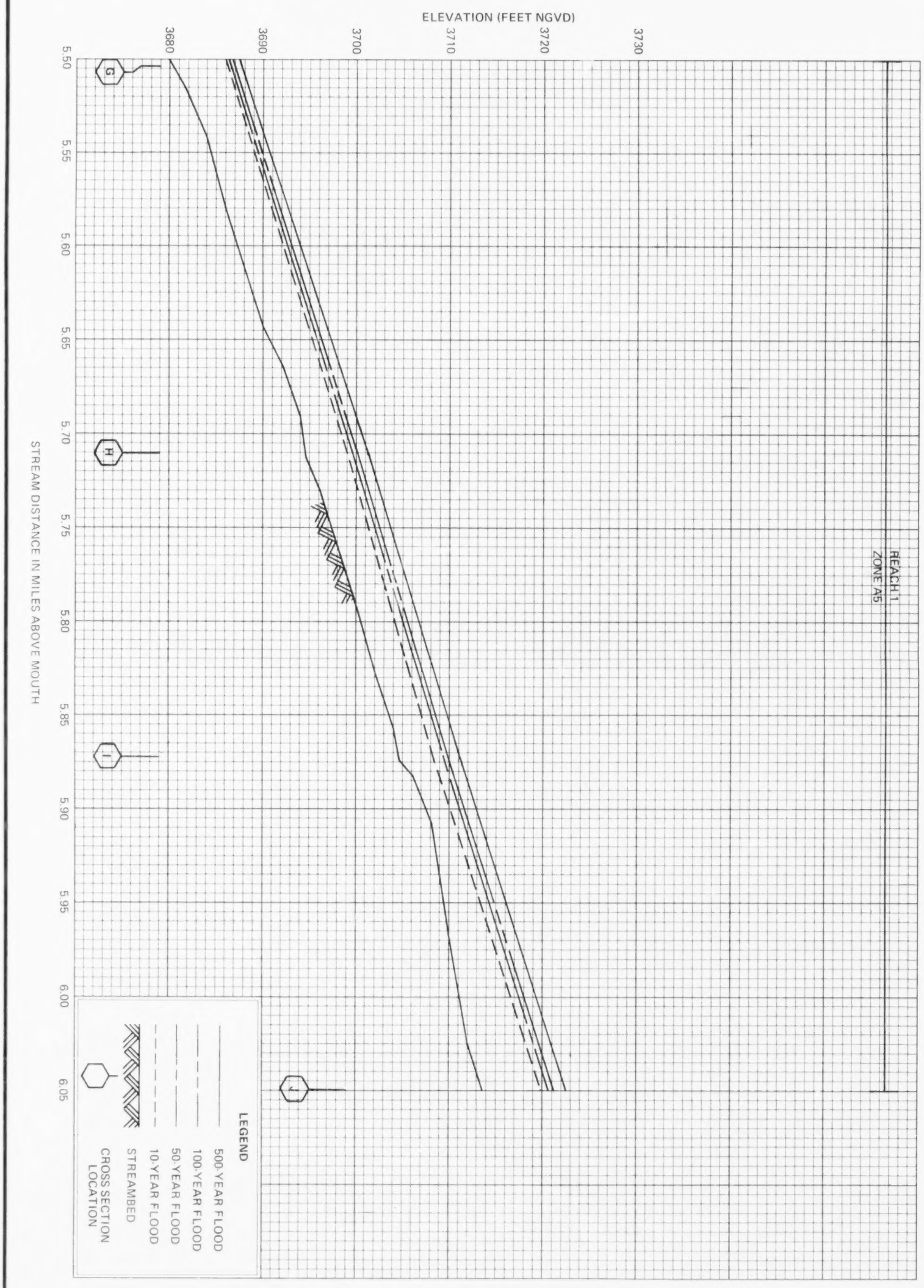
02P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

POTRERO CREEK



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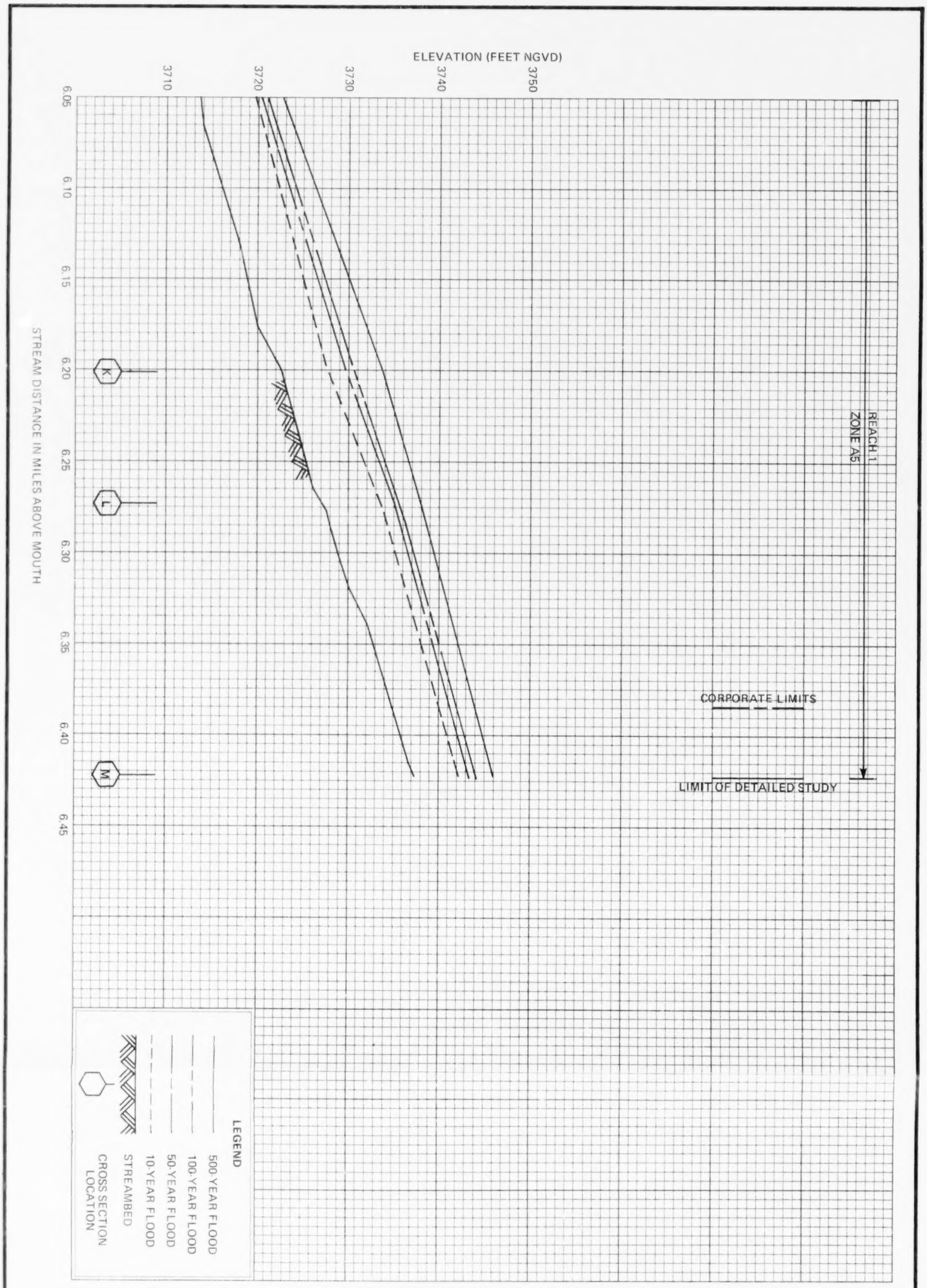


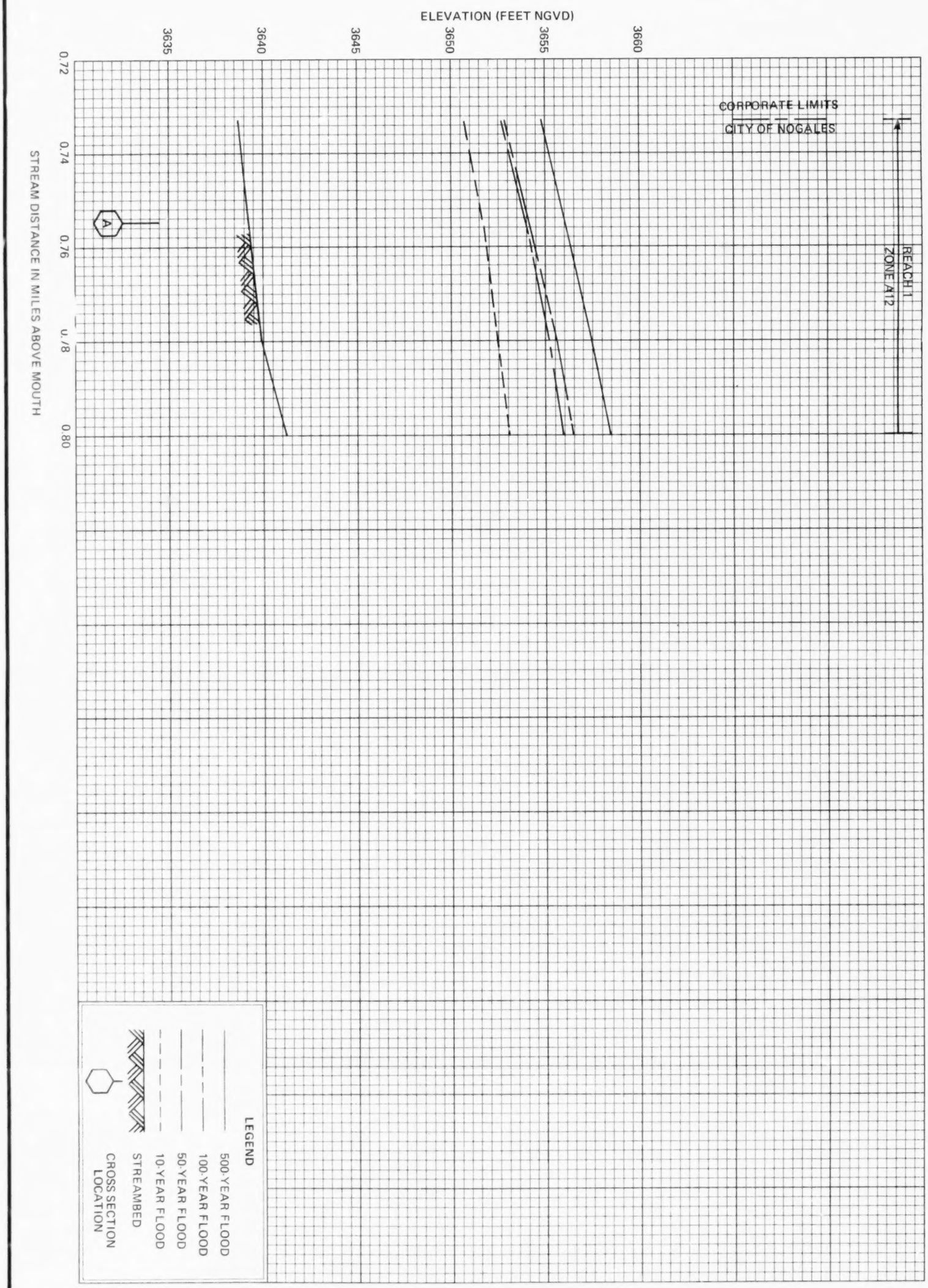
04P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

POTRERO CREEK



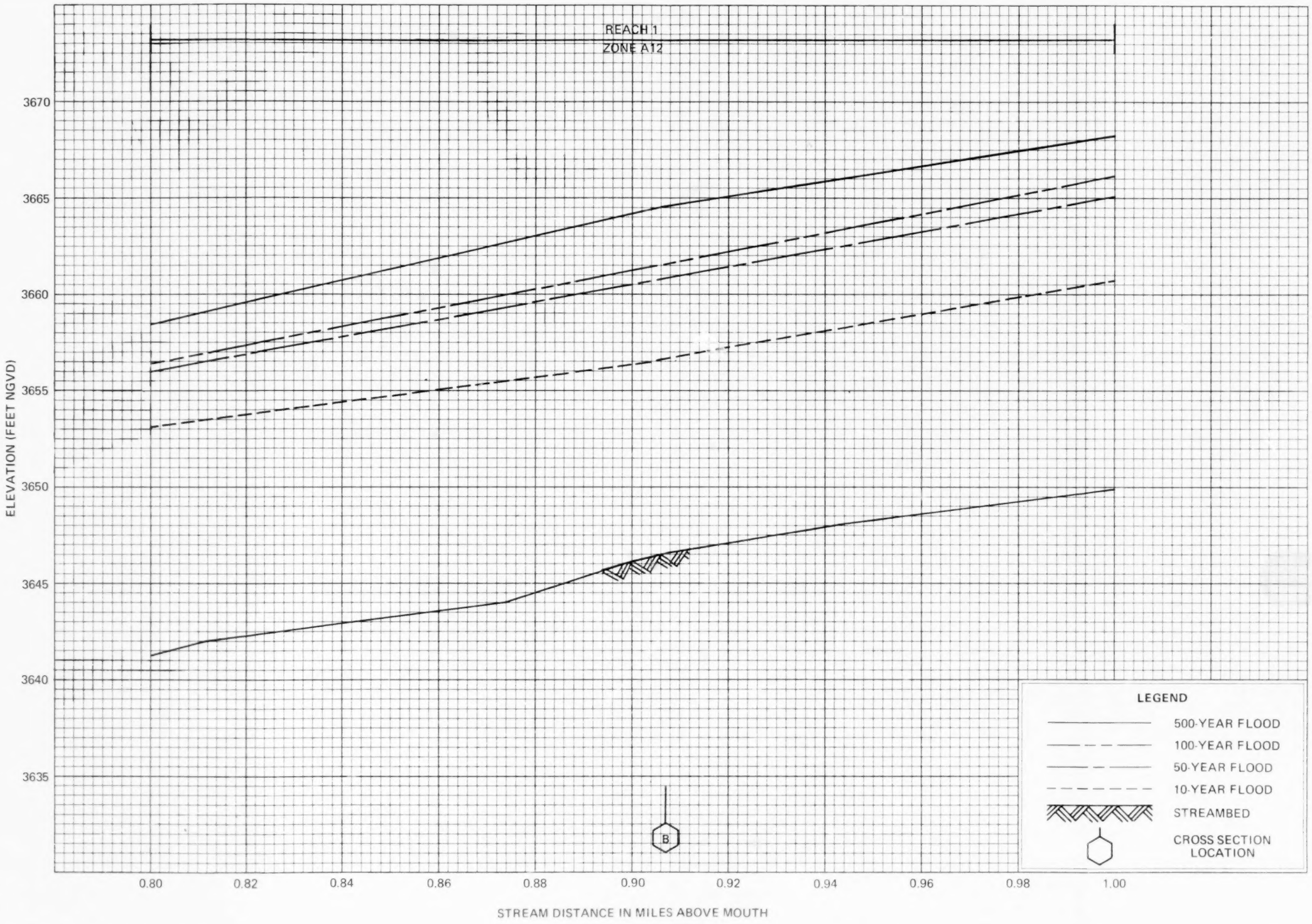
05P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
[SANTA CRUZ CO.]

FLOOD PROFILES

NOGALES WASH



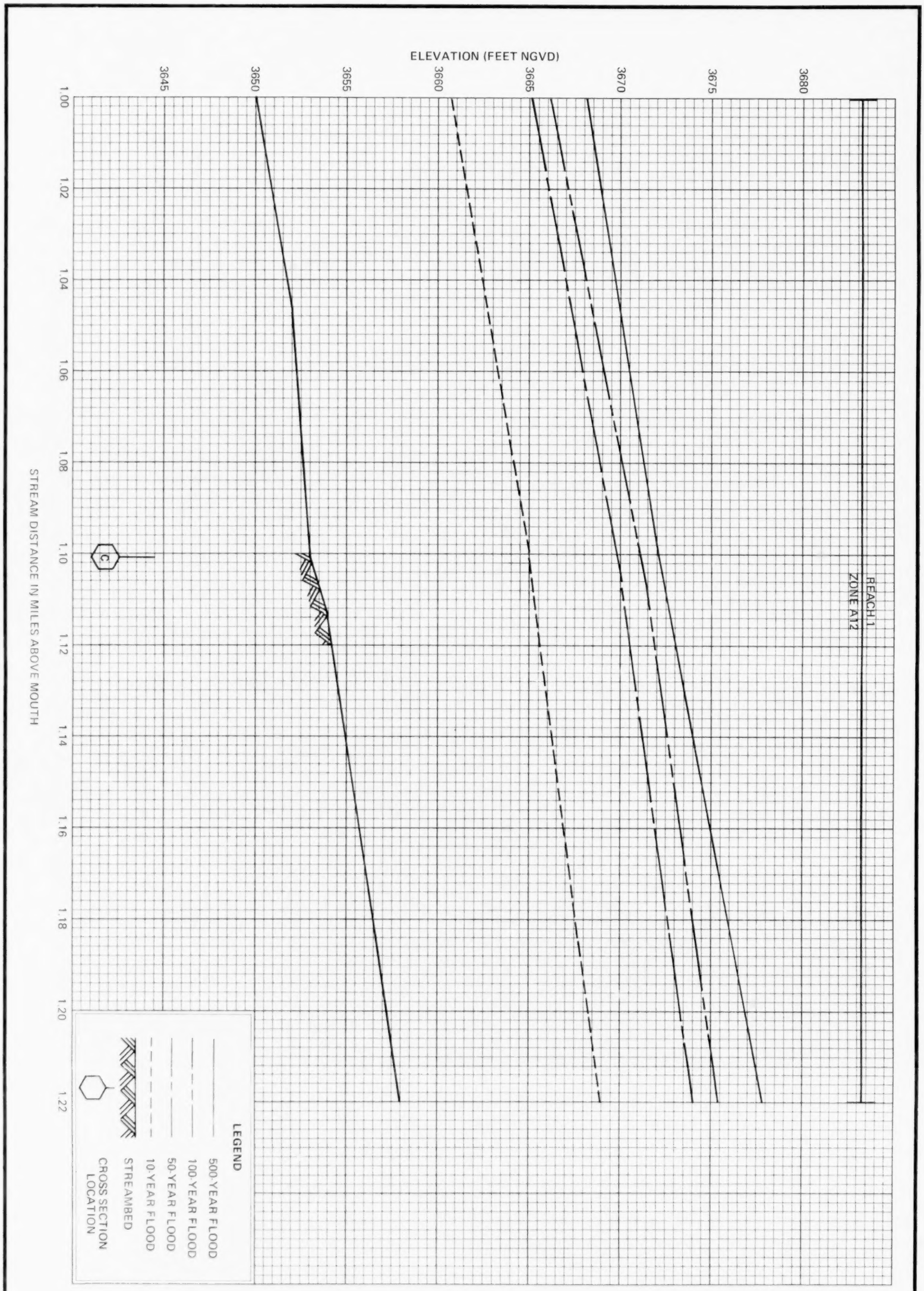
FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

06P



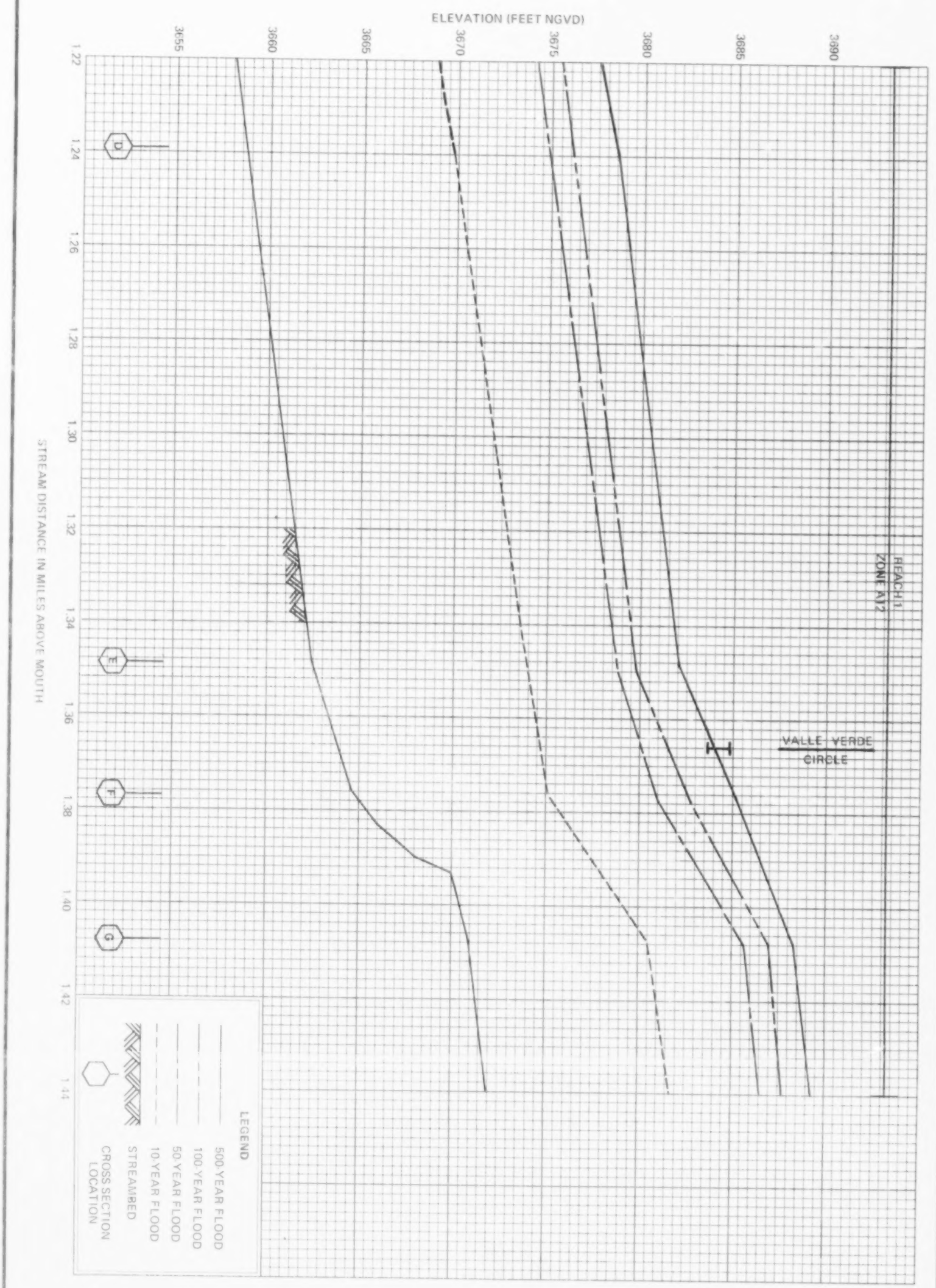
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH

07P



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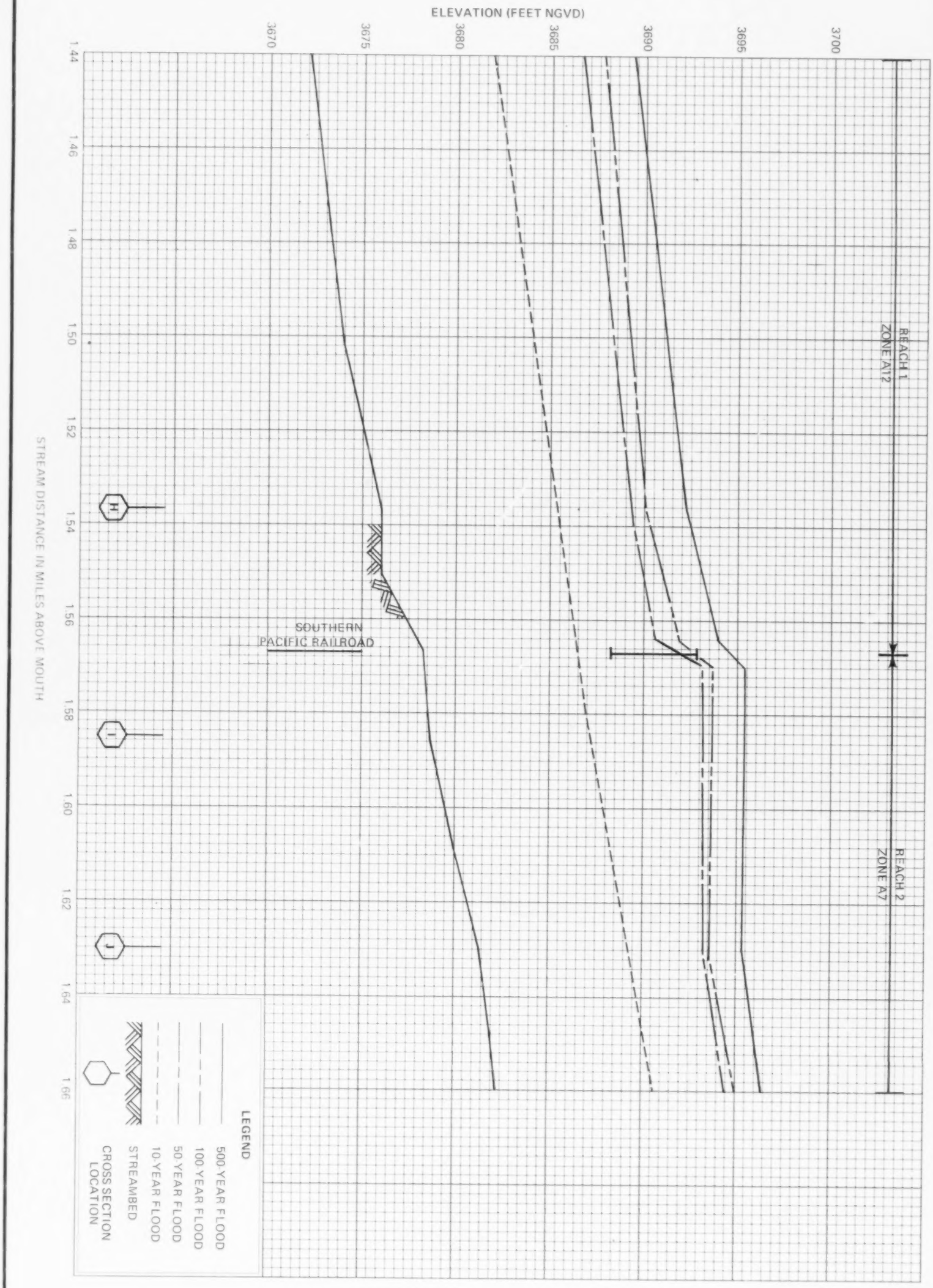
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH

08P



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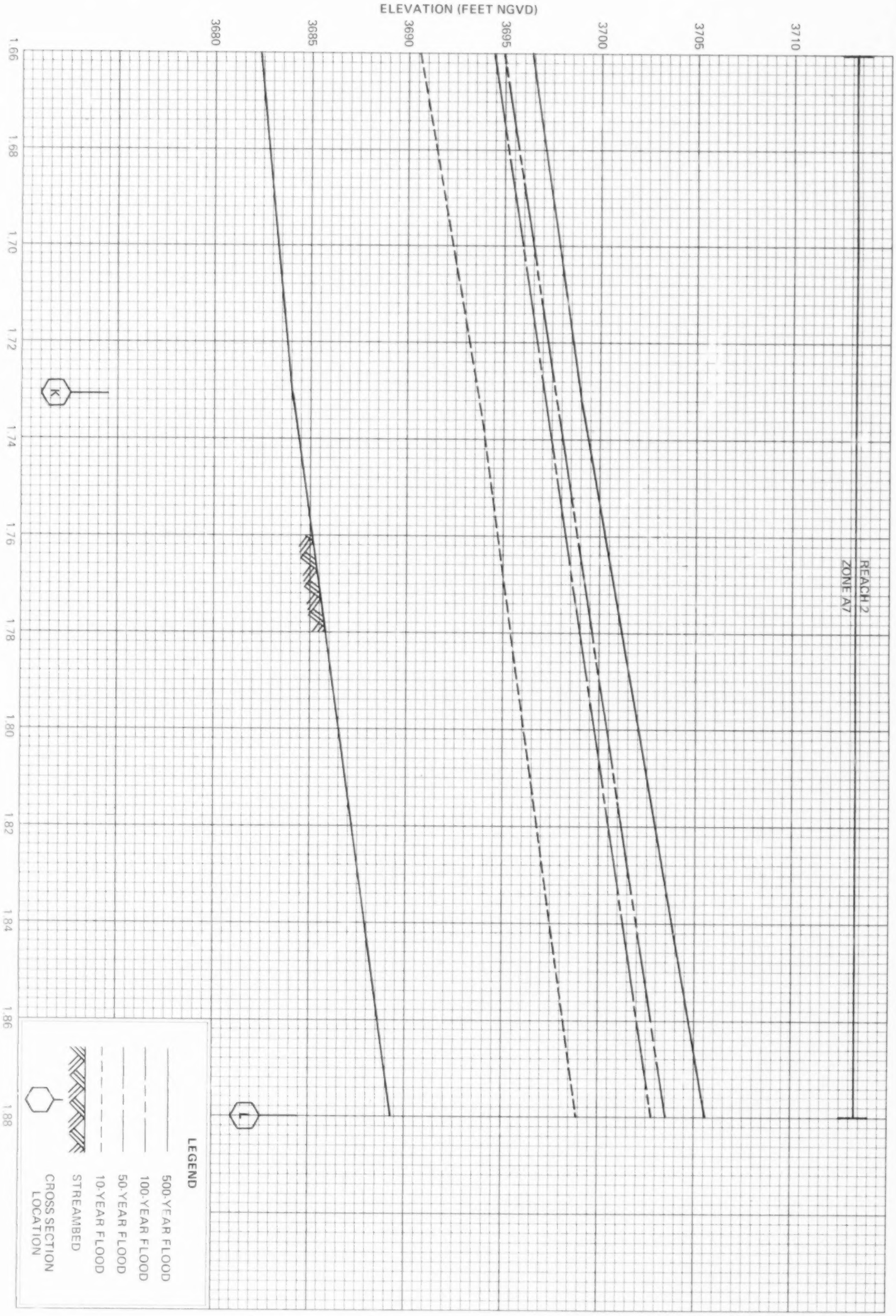


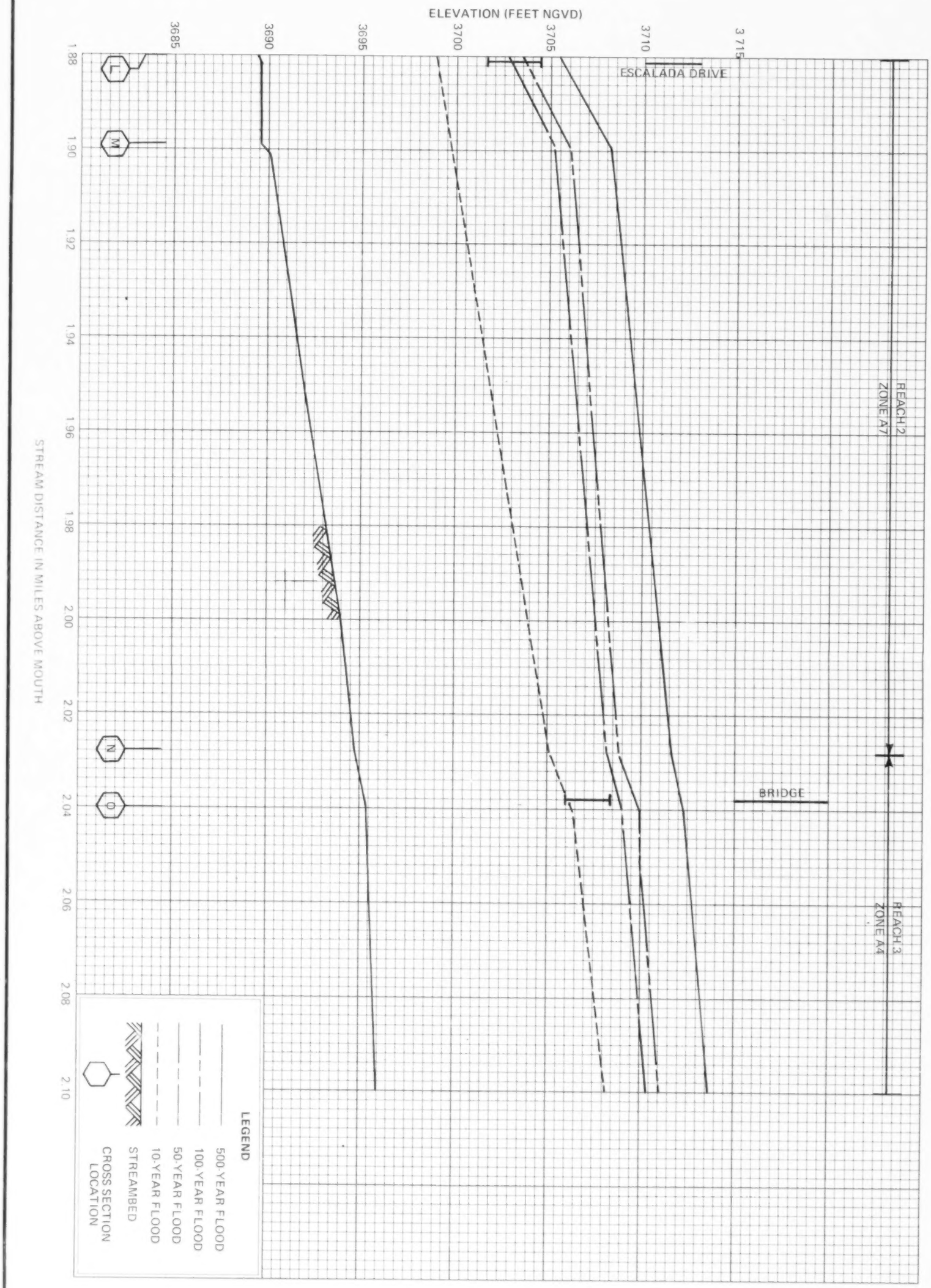
10P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH



11P	FEDERAL EMERGENCY MANAGEMENT AGENCY Federal Insurance Administration CITY OF NOGALES, AZ (SANTA CRUZ CO.)	FLOOD PROFILES NOGALES WASH

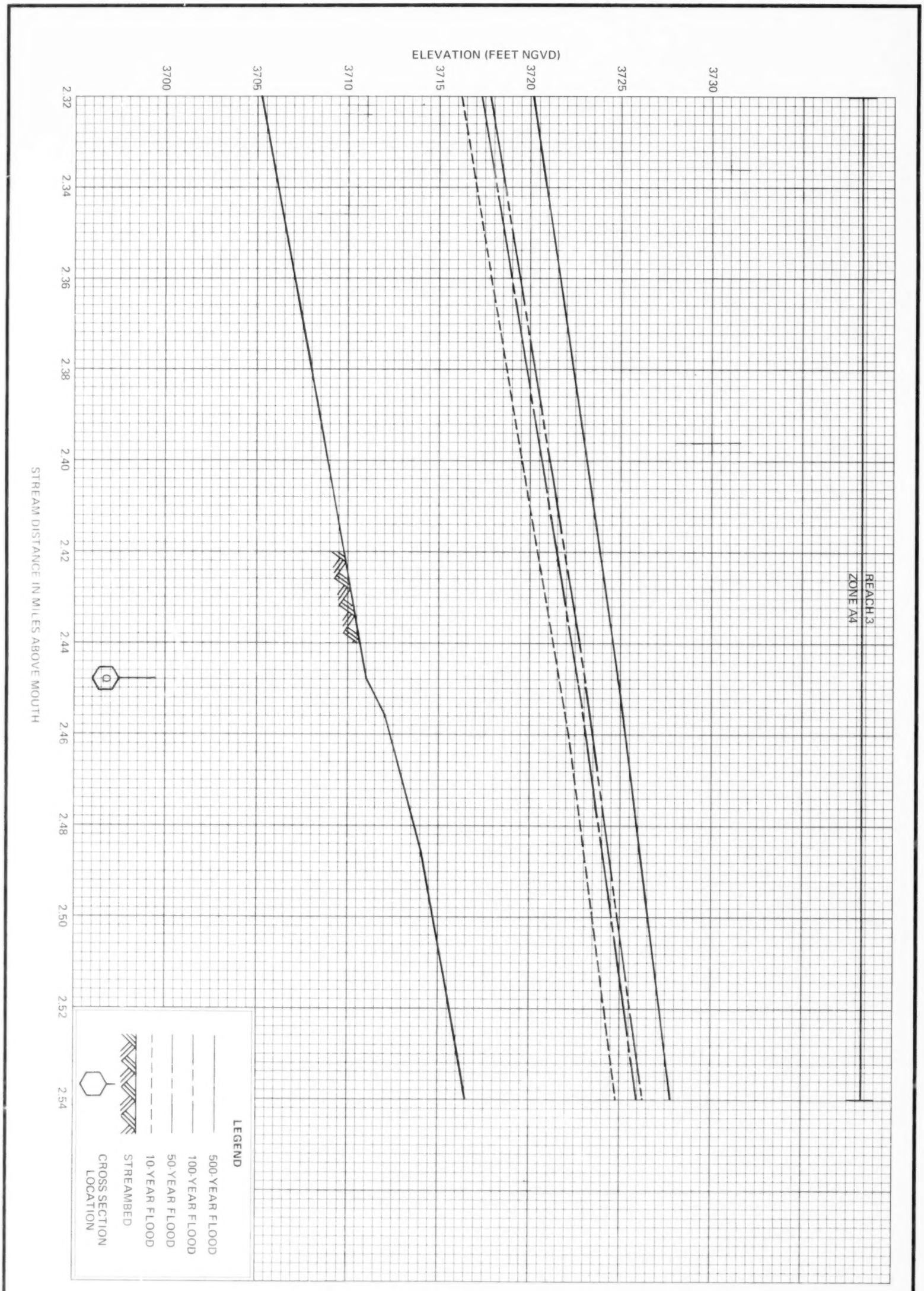
12P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

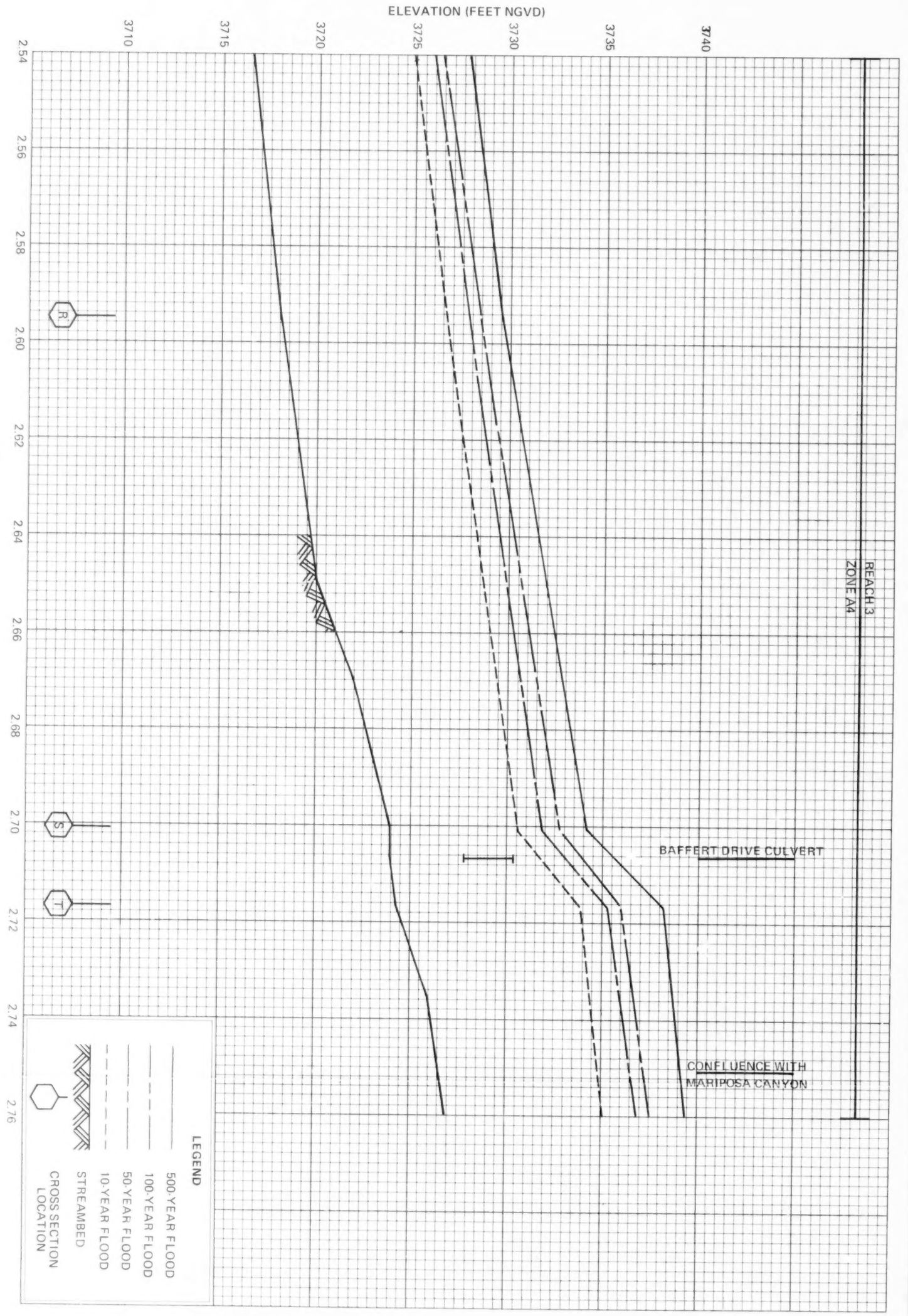
CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH



13P	FEDERAL EMERGENCY MANAGEMENT AGENCY Federal Insurance Administration CITY OF NOGALES, AZ (SANTA CRUZ CO.)	FLOOD PROFILES NOGALES WASH



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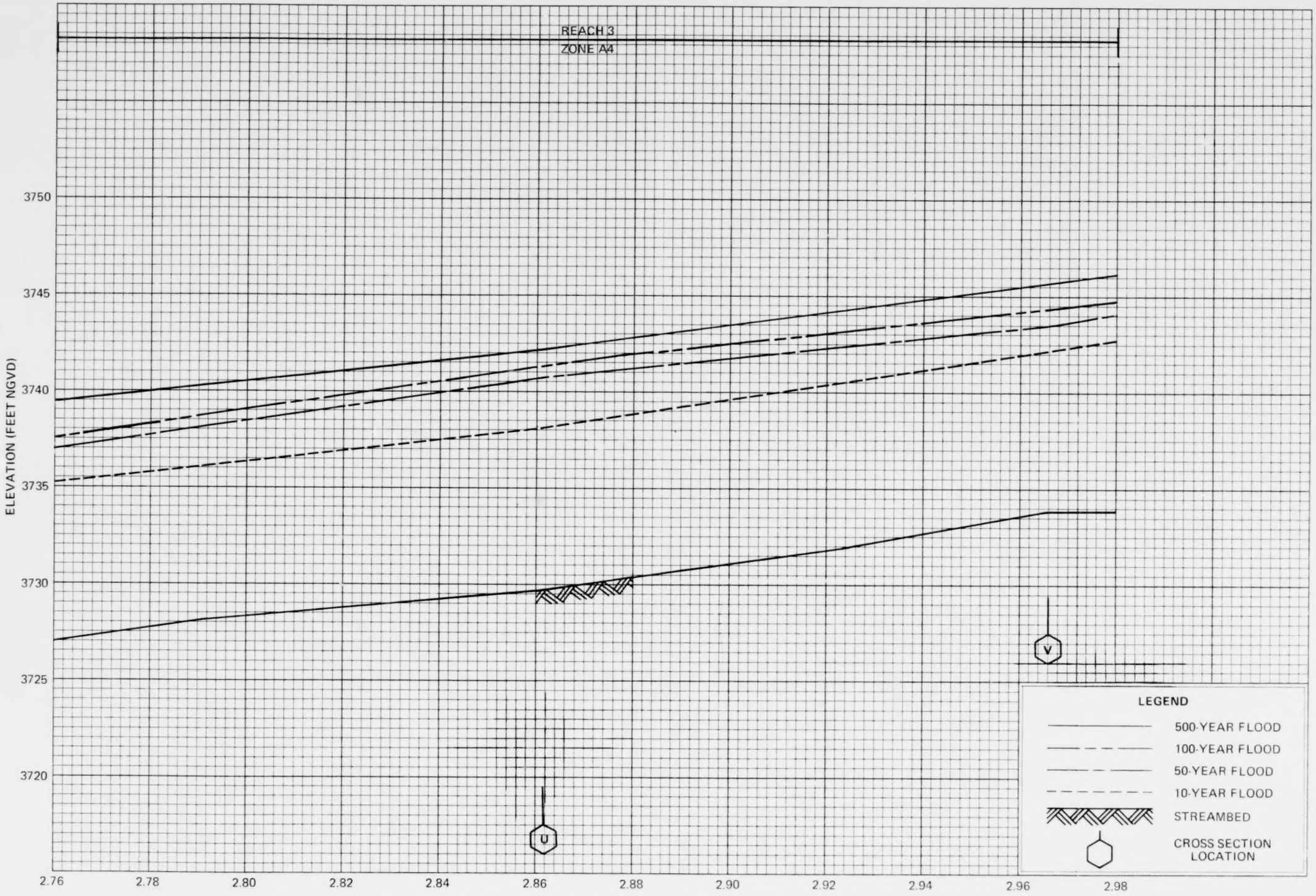
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH



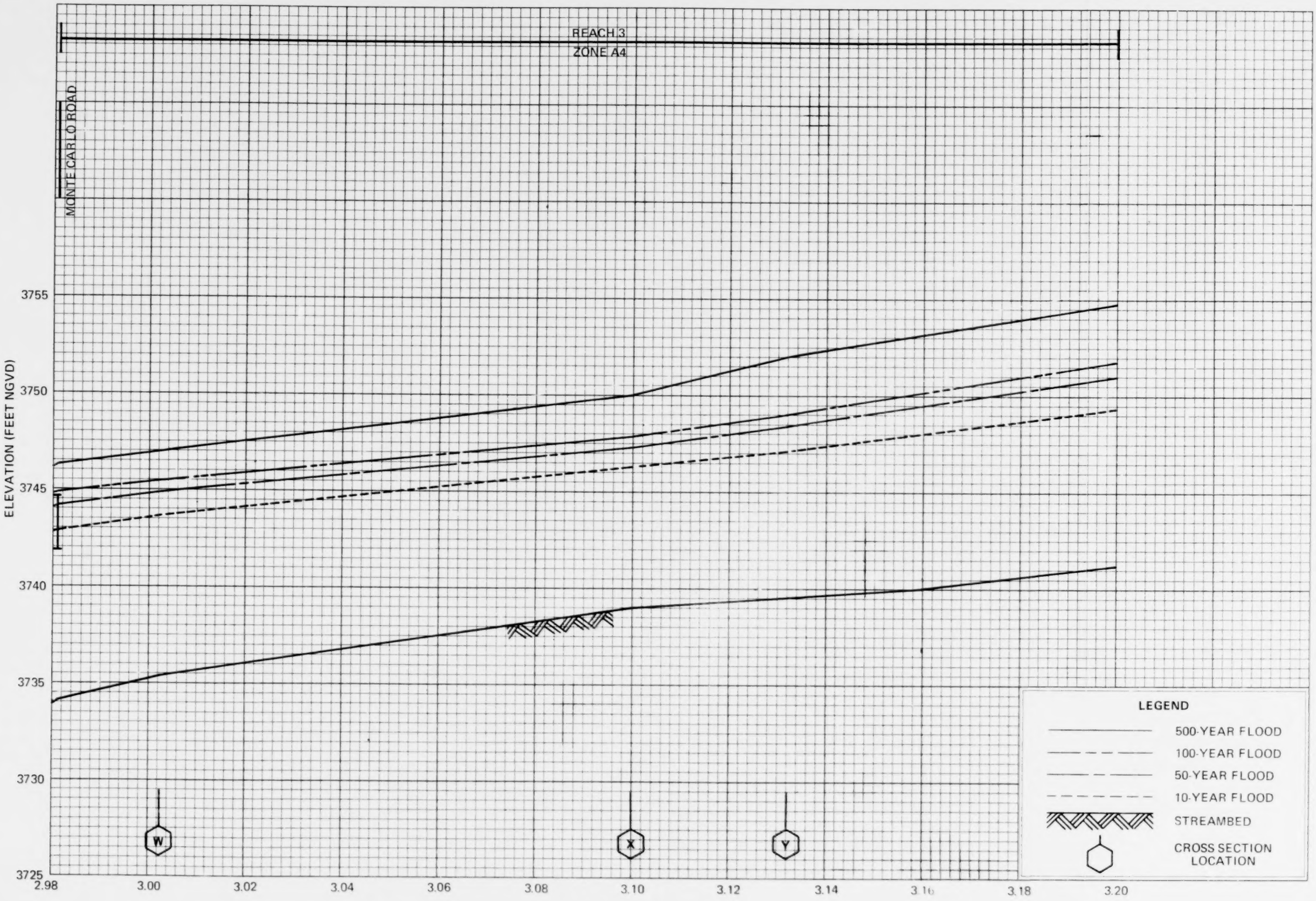
FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

15P



FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

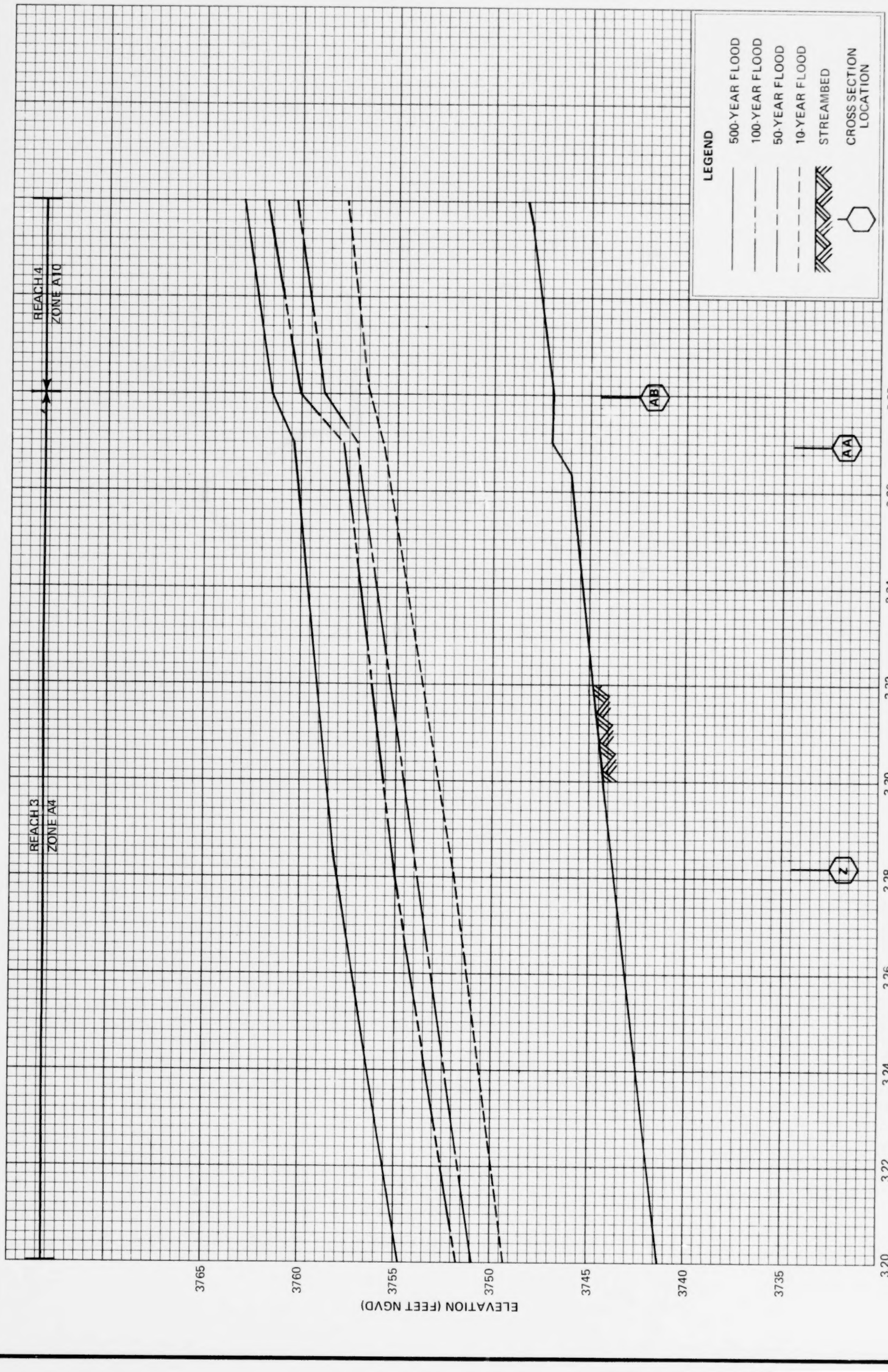
16P

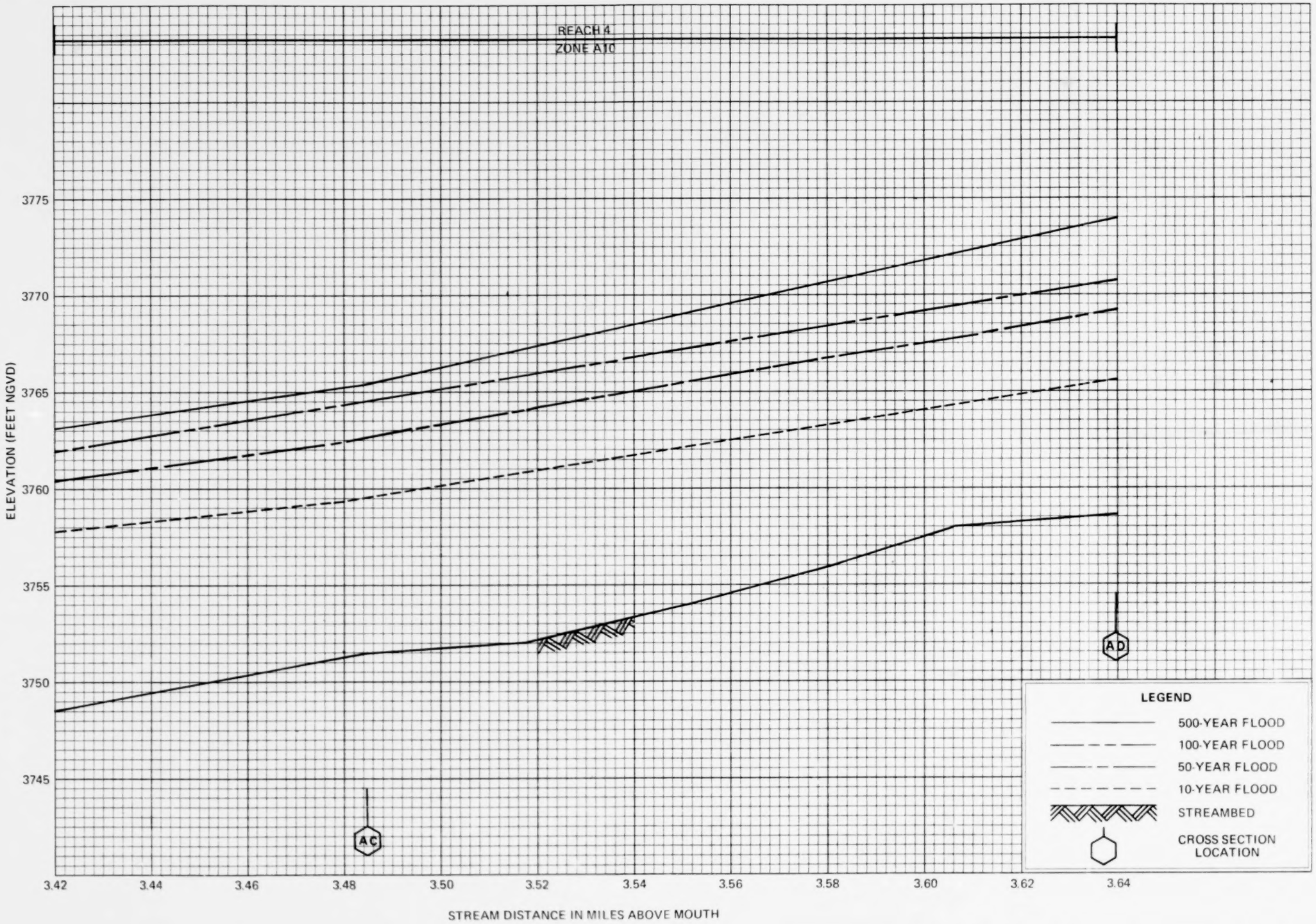
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH





FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
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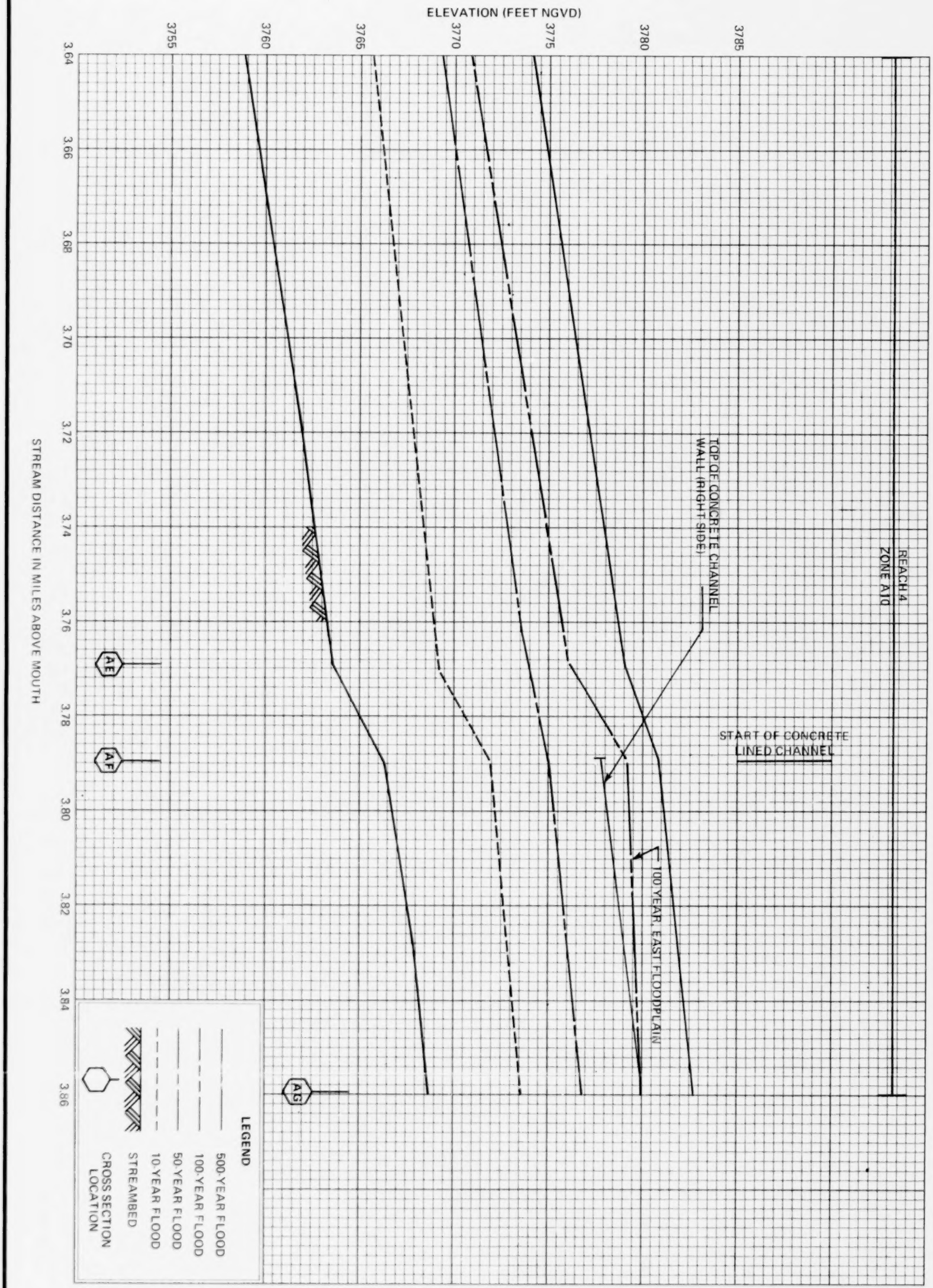
CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

18P



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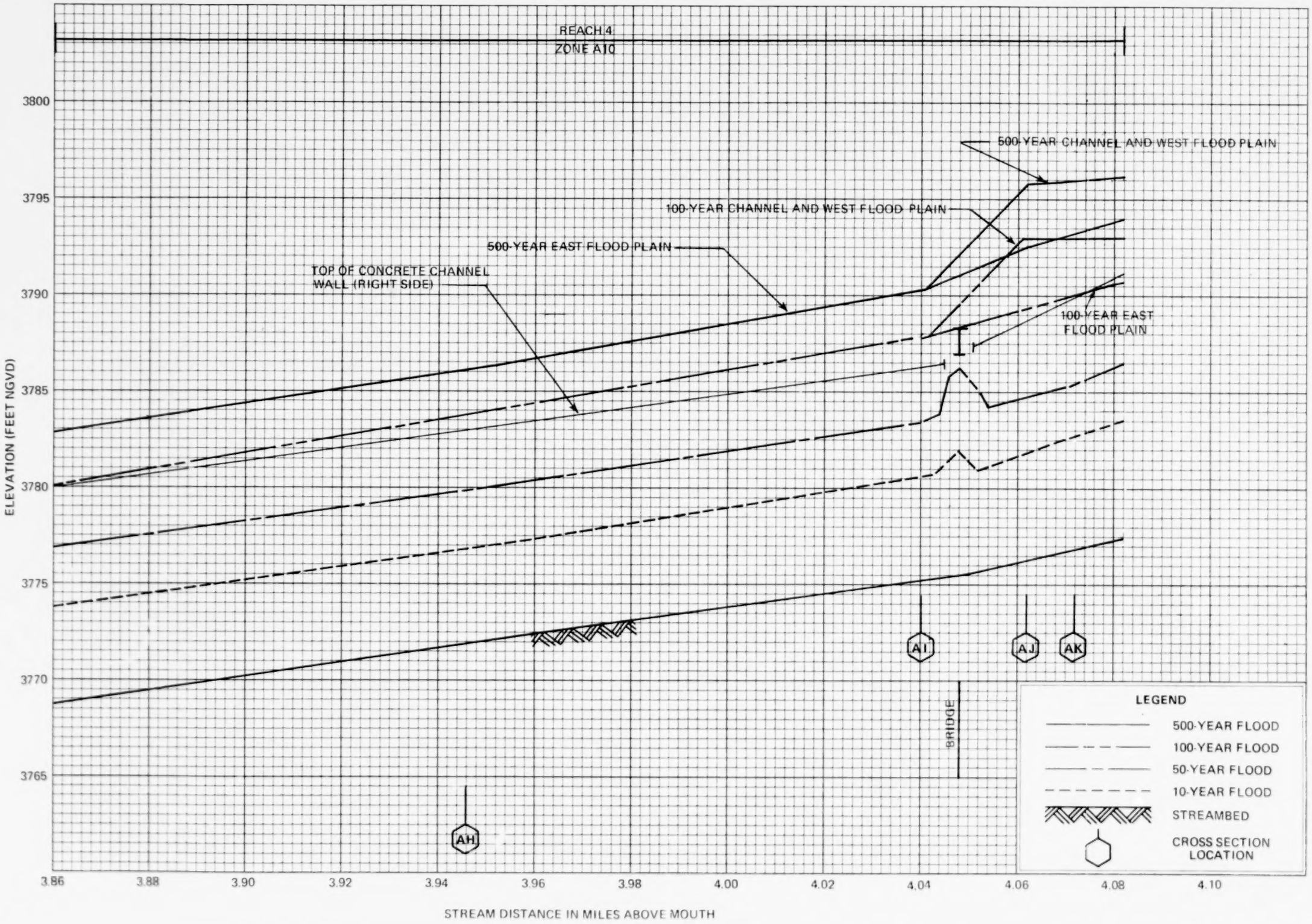
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH AND NOGALES WASH EAST FLOOD PLAIN



FLOOD PROFILES

NOGALES WASH AND NOGALES WASH EAST AND WEST FLOOD PLAINS

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Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

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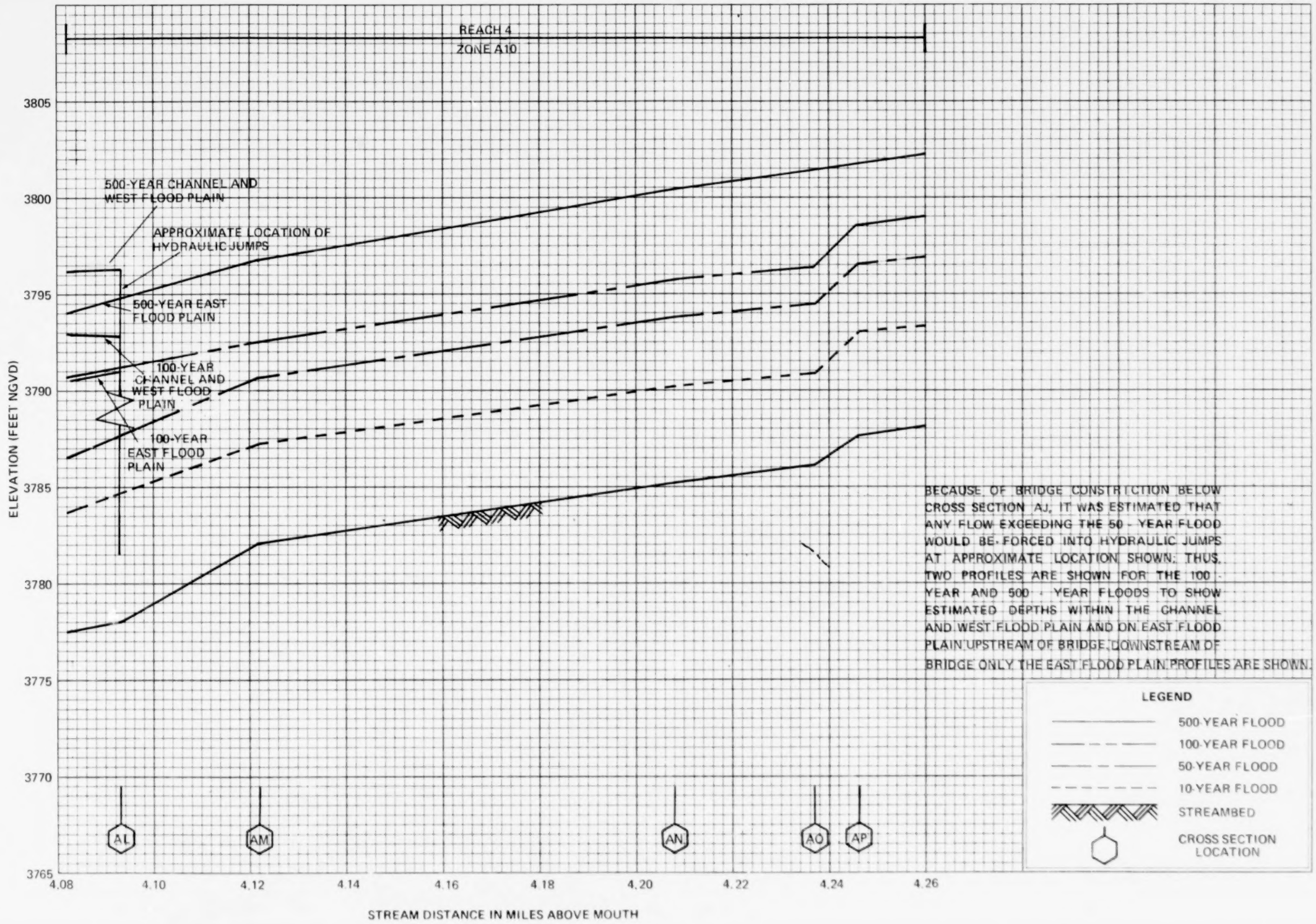

FLOOD PROFILES

NOGALES WASH AND NOGALES WASH EAST AND WEST FLOOD PLAINS

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

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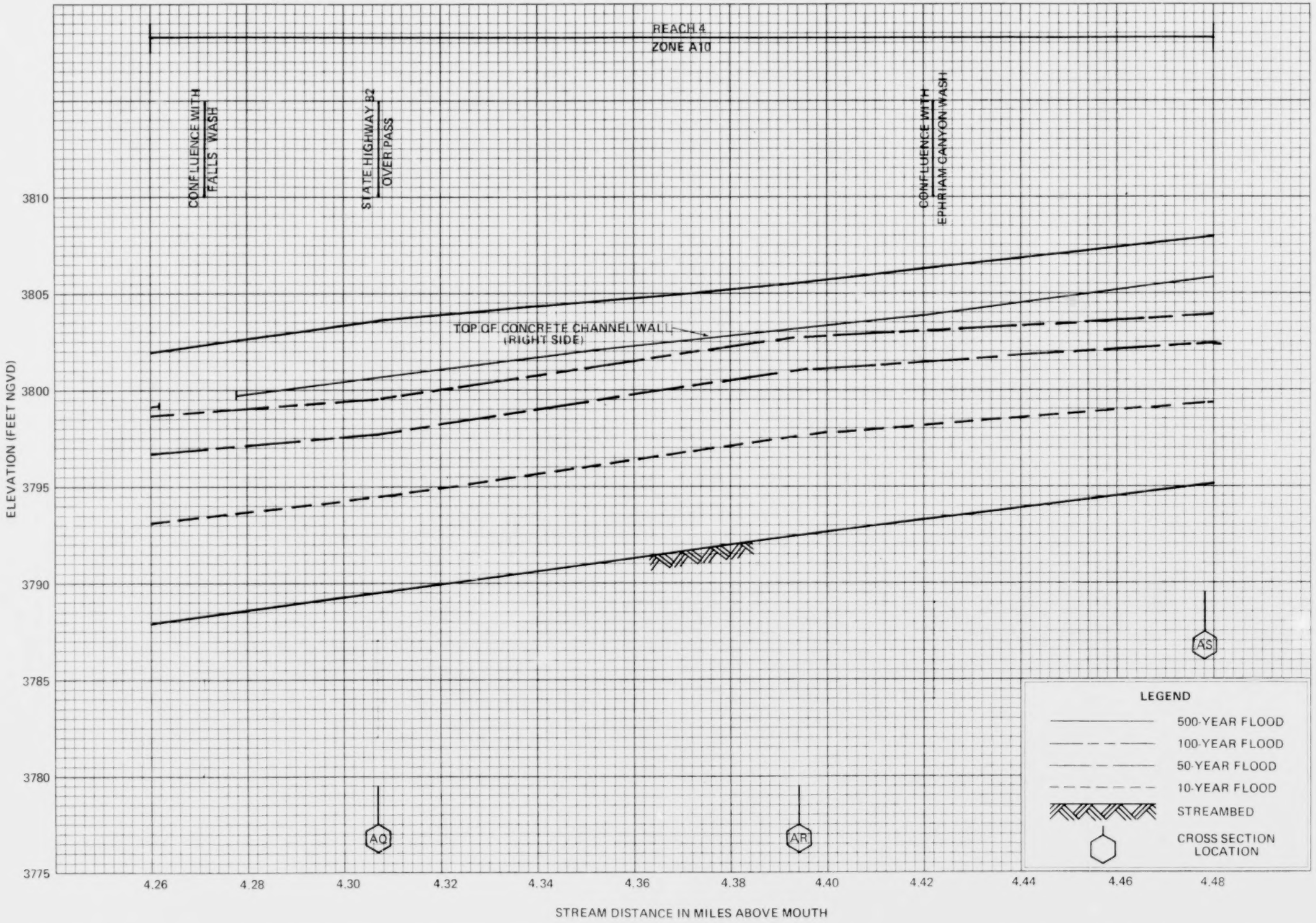

FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

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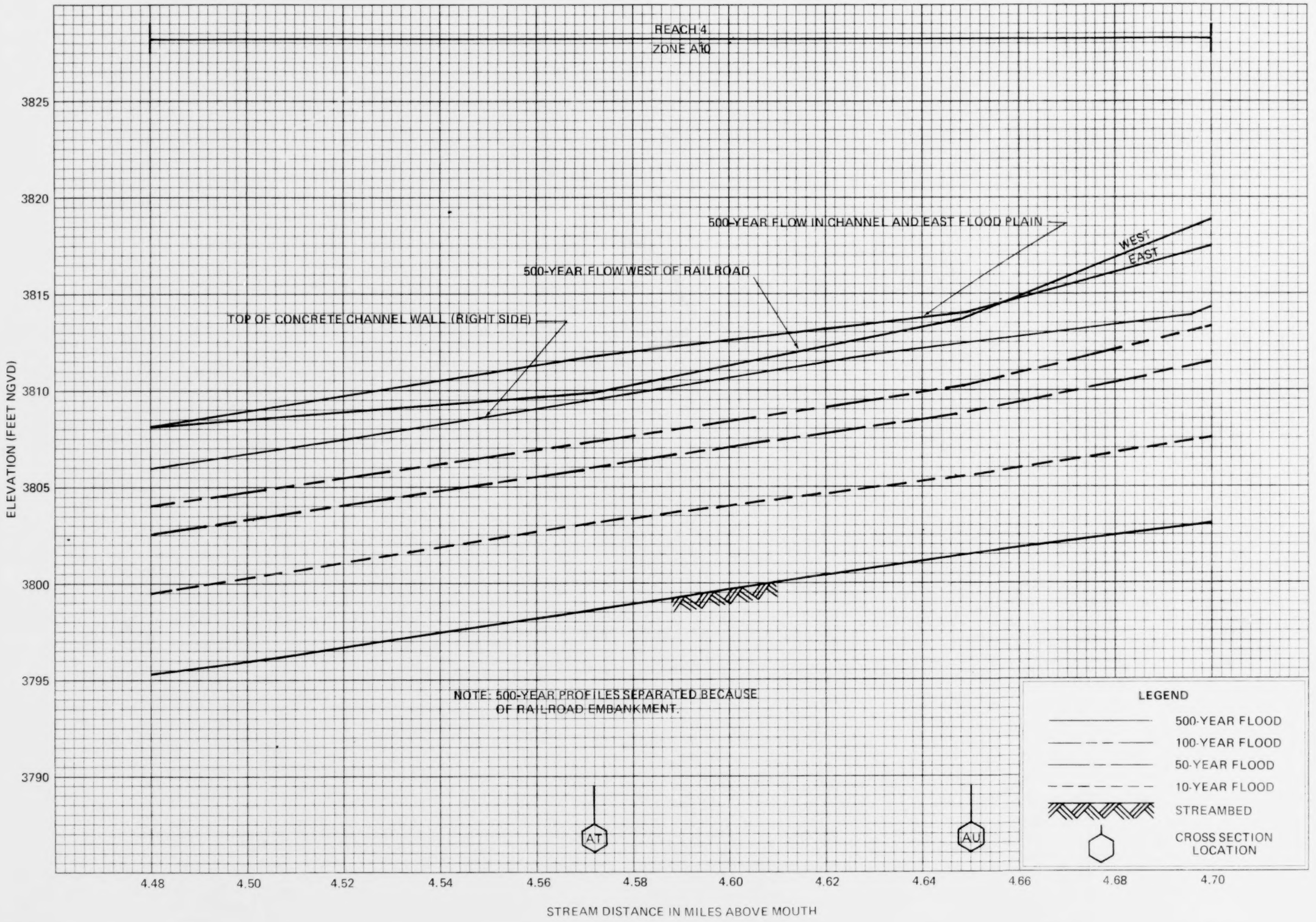

FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

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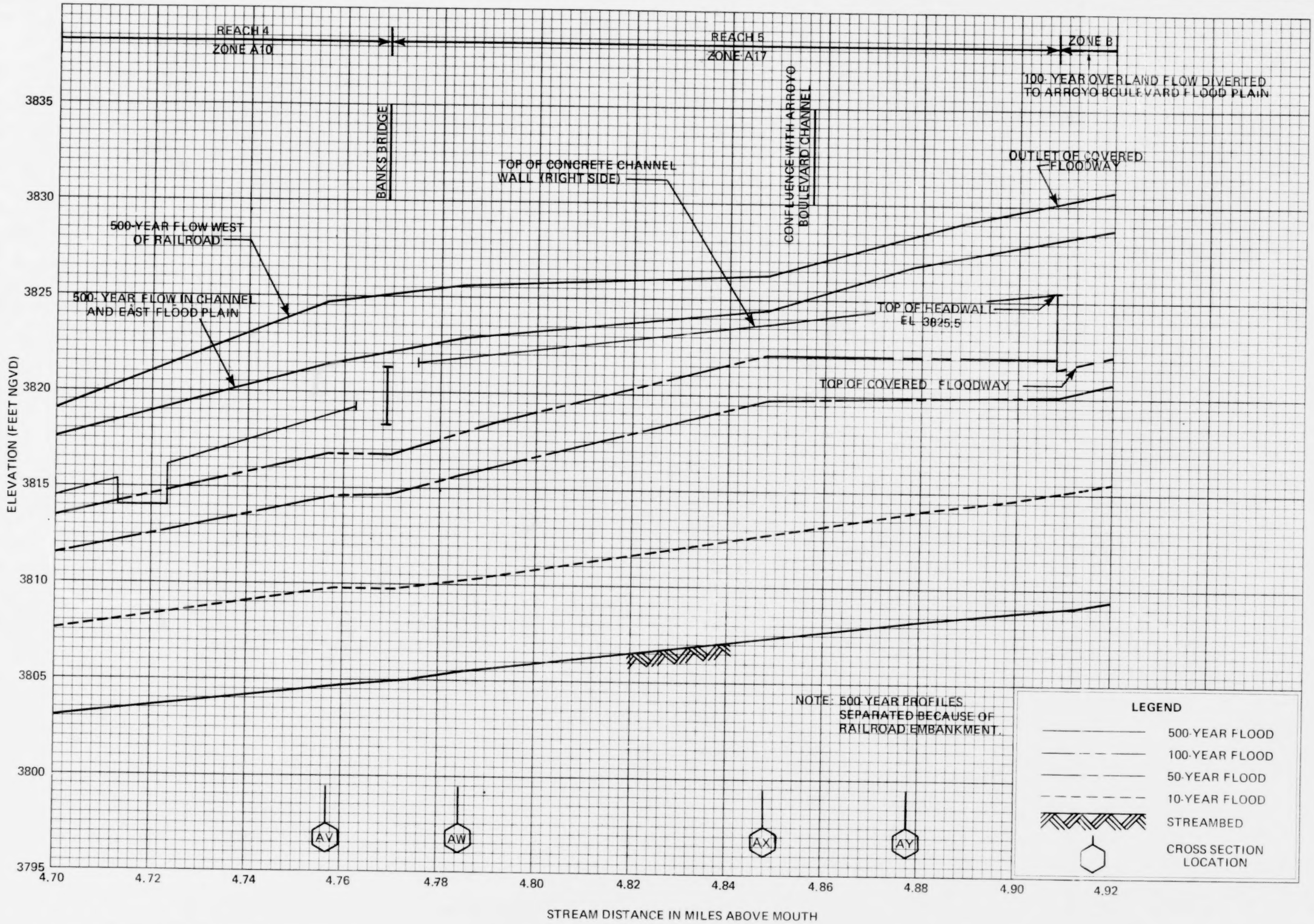


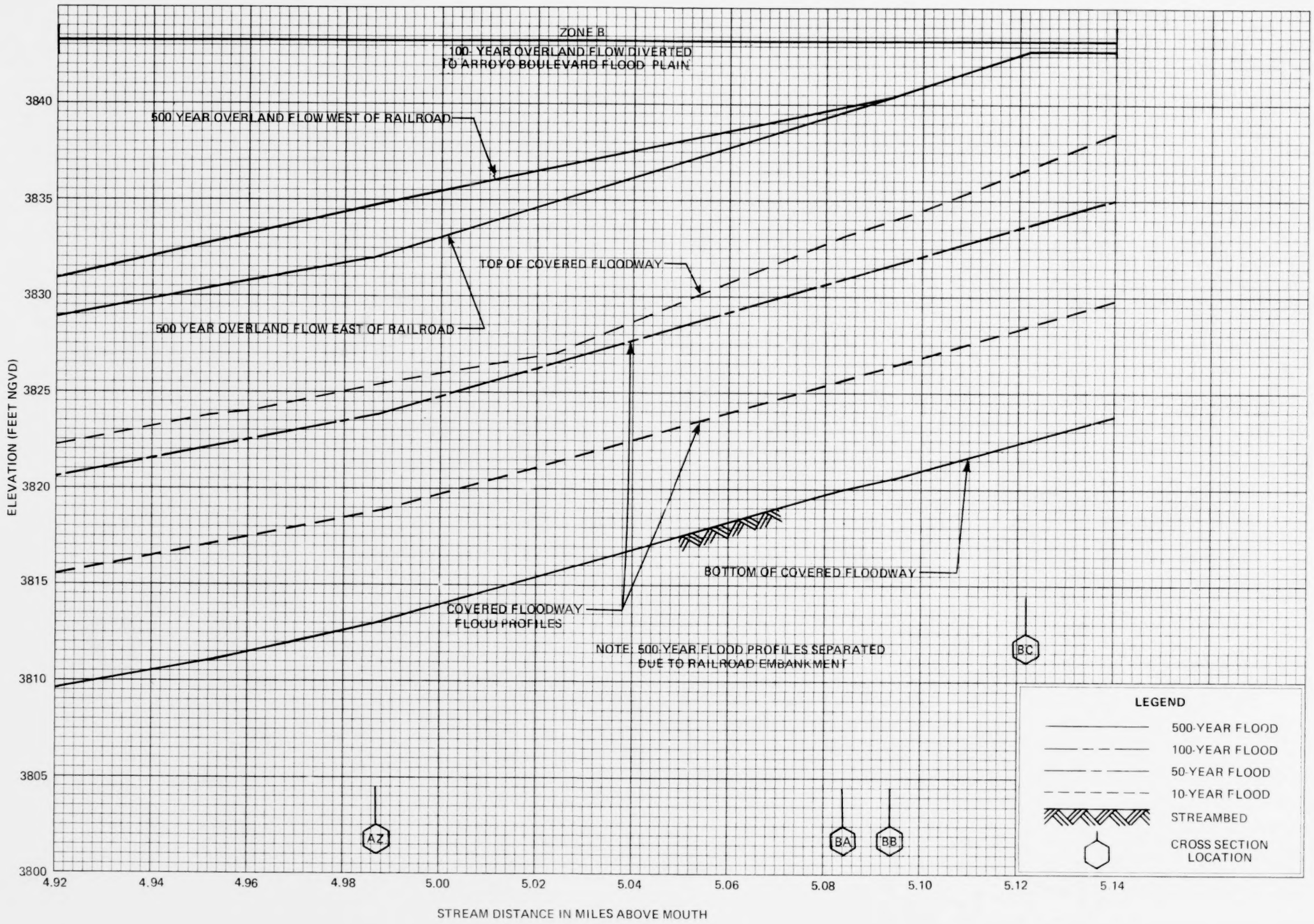
FLOOD PROFILES

NOGALES WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

24P



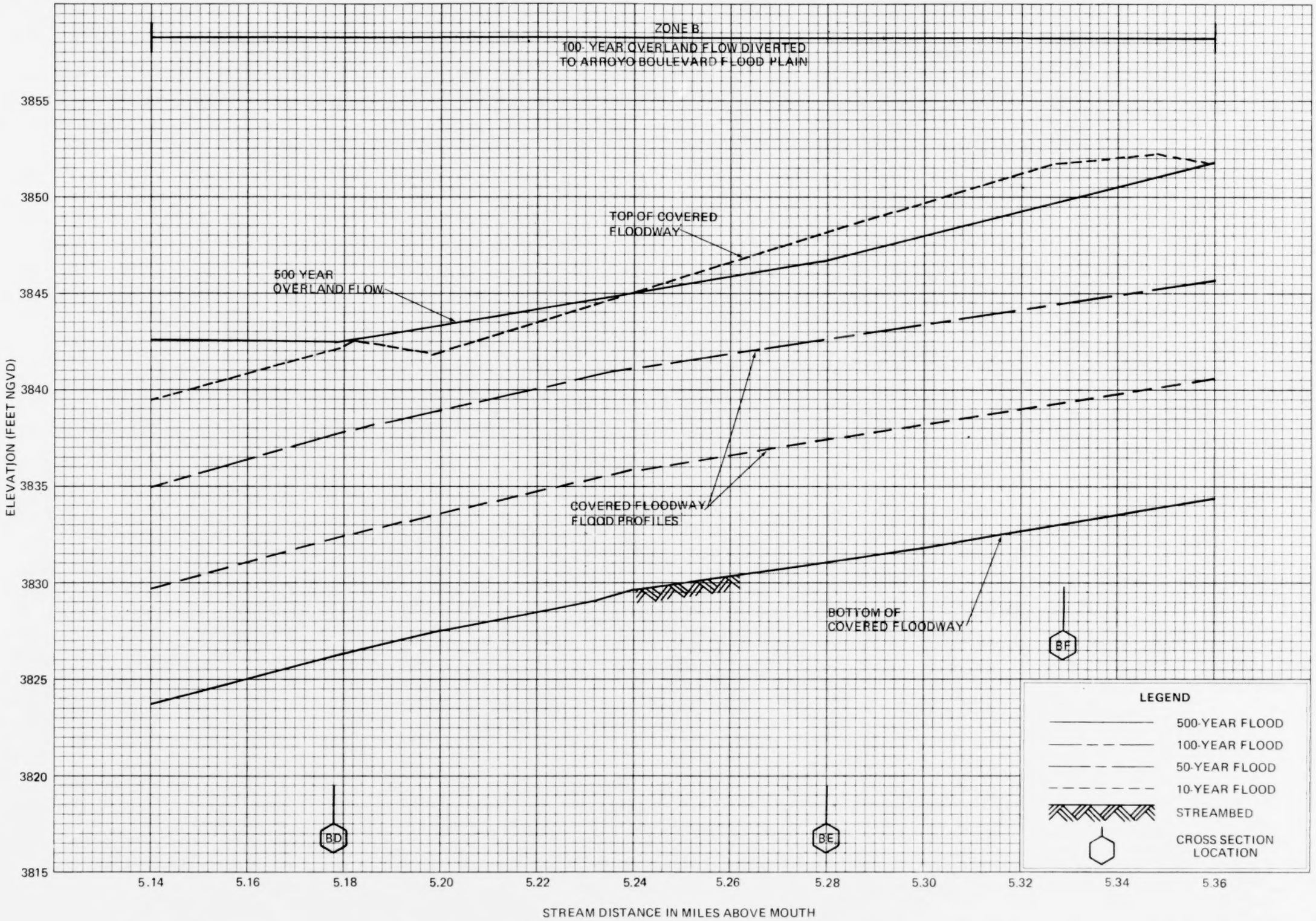
FLOOD PROFILES

NOGALES WASH-COVERED FLOODWAY AND 500-YEAR OVERLAND FLOW

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

25P



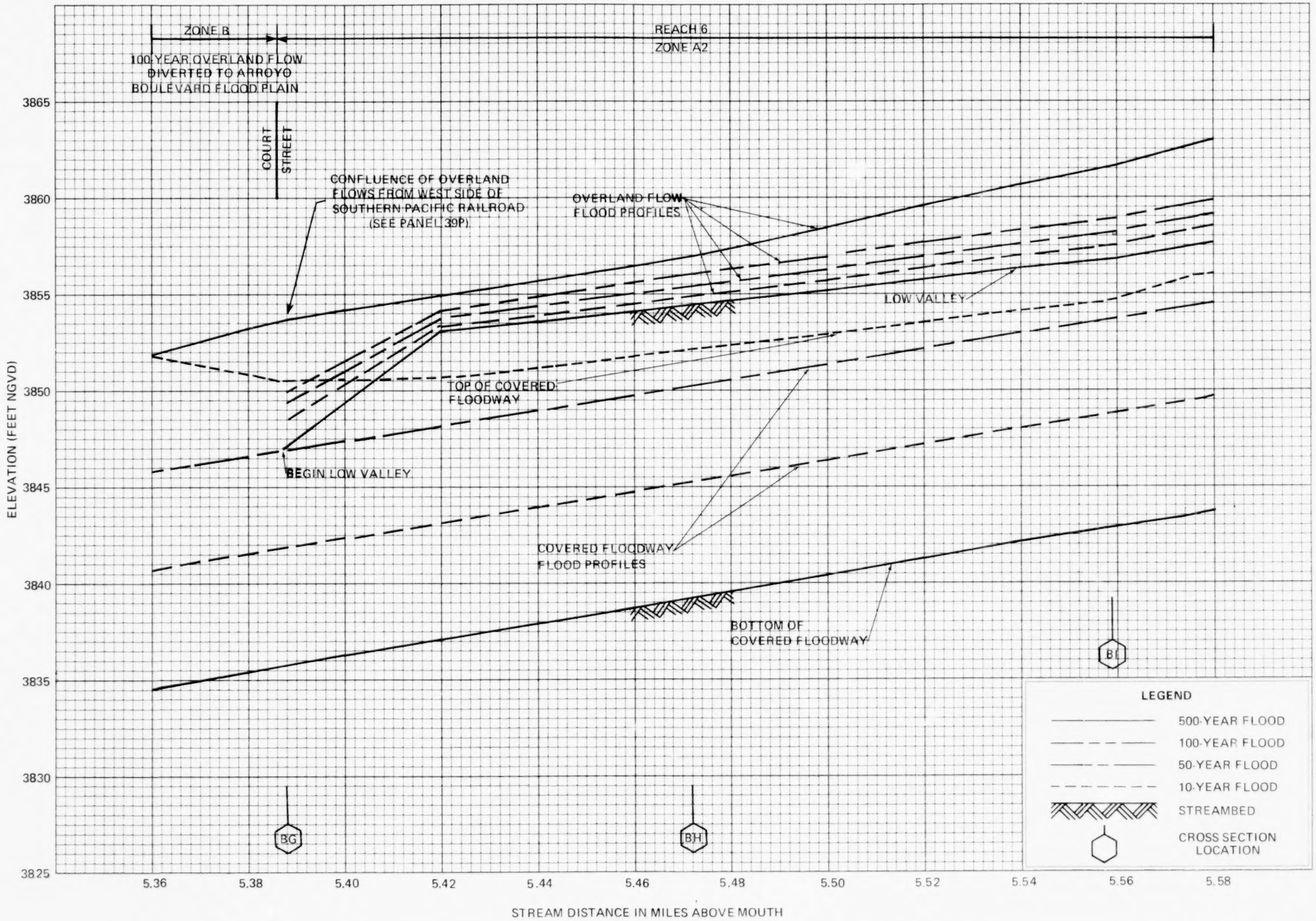
FLOOD PROFILES

NOGALES WASH-COVERED FLOODWAY AND 500-YEAR OVERLAND FLOW

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

26P



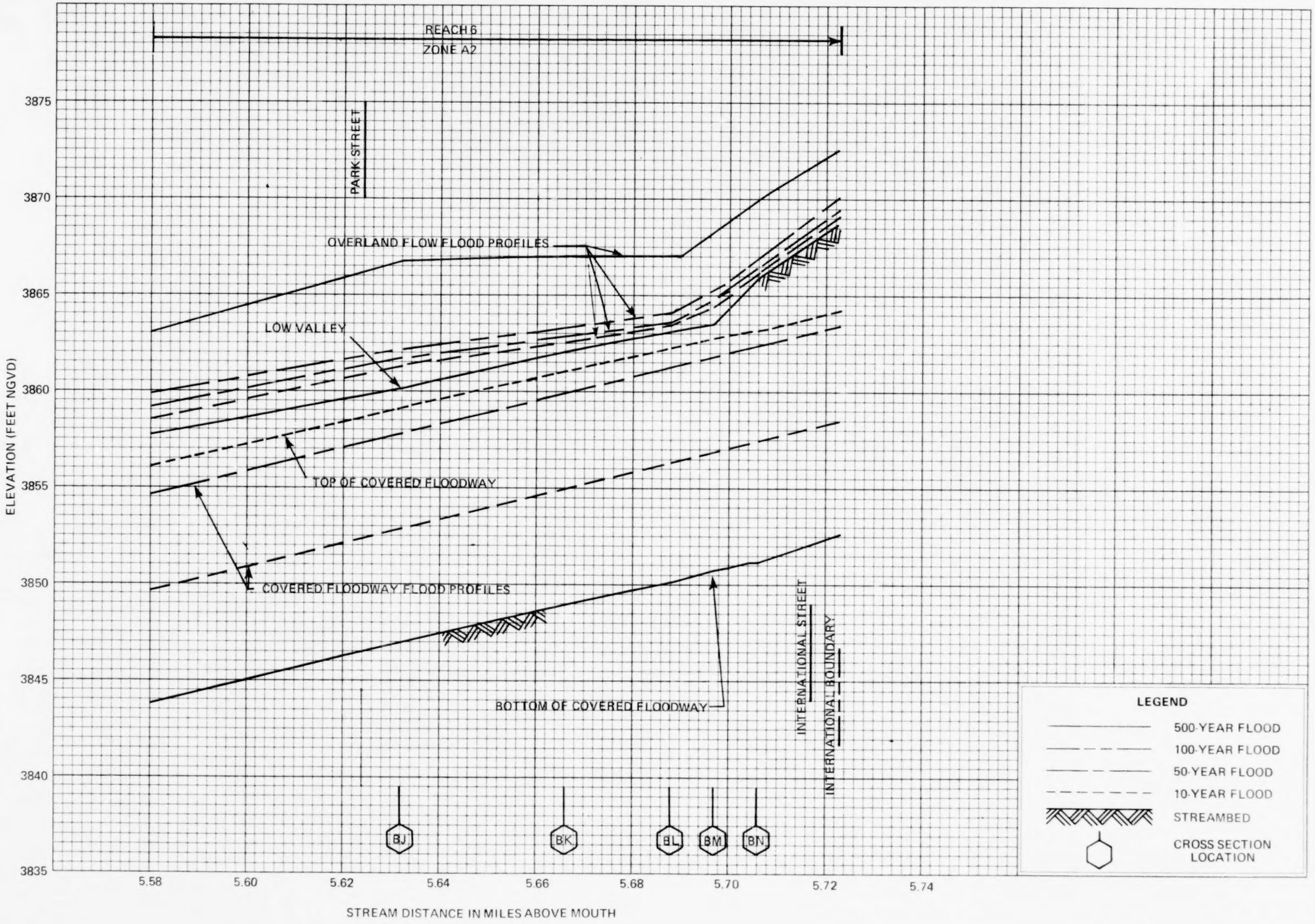
FLOOD PROFILES

NOGALES WASH-COVERED FLOODWAY AND
OVERLAND FLOW EAST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

27P



FLOOD PROFILES

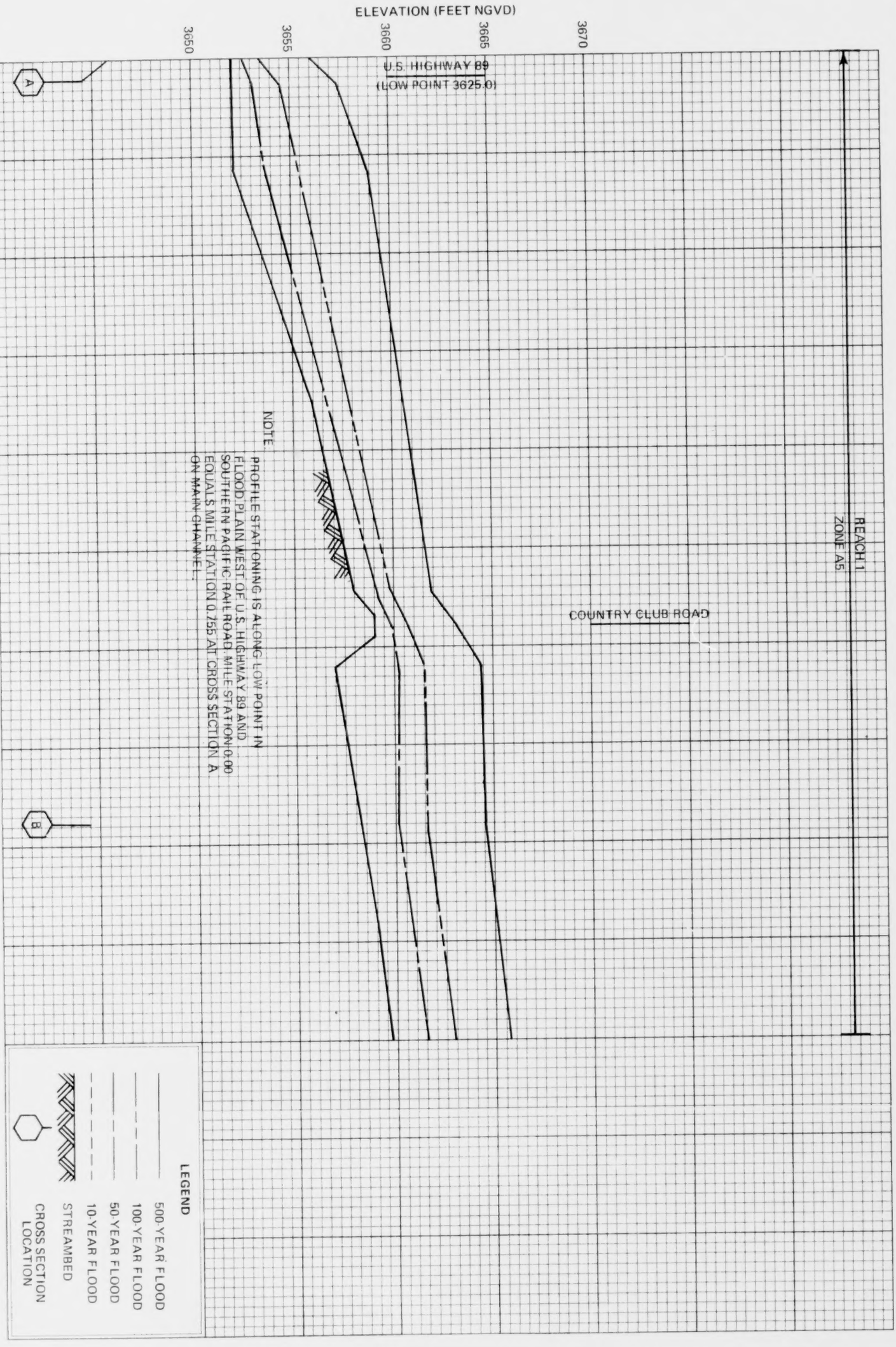
NOGALES WASH-COVERED FLOODWAY AND
OVERLAND FLOW EAST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

28P



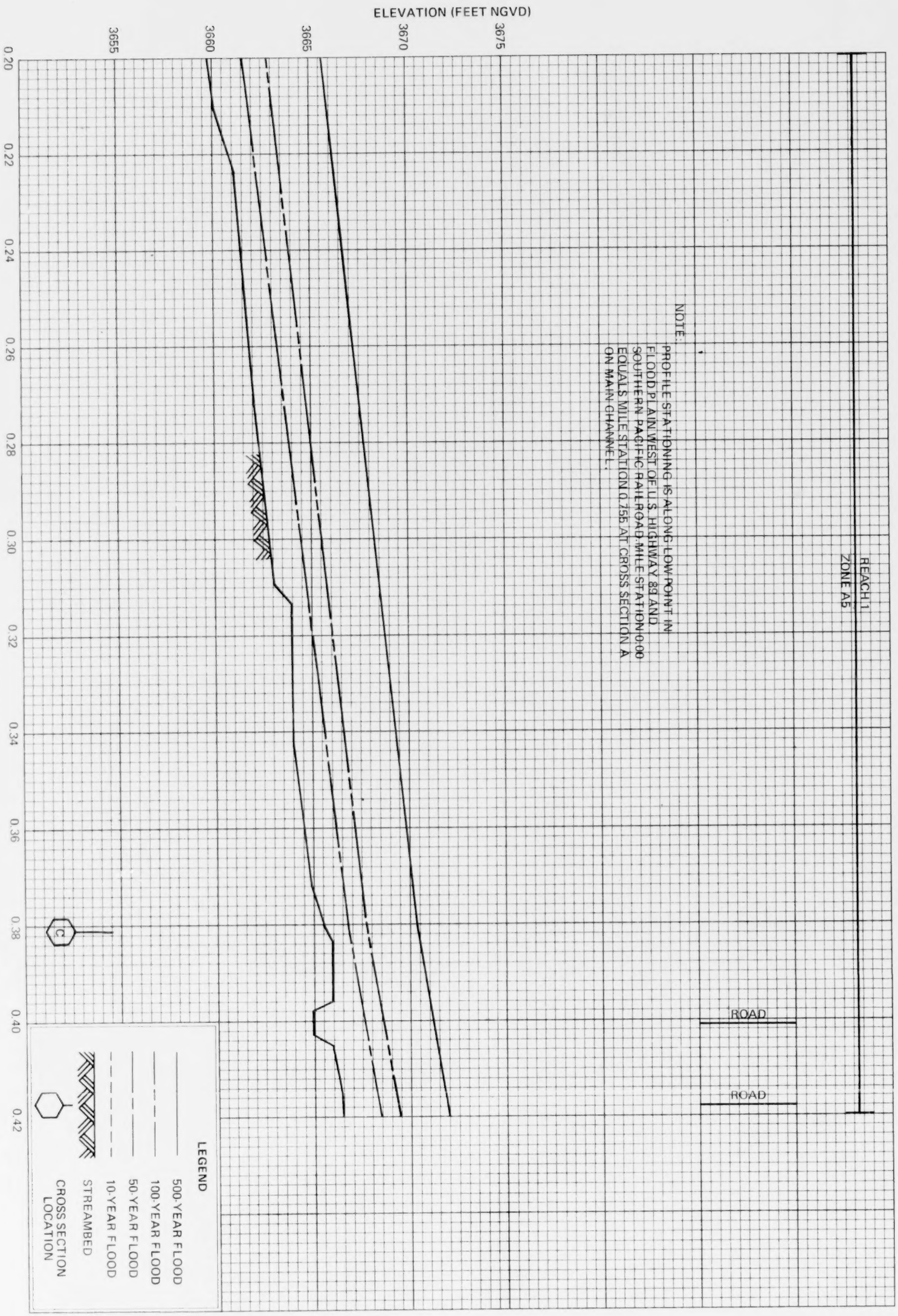
29P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC PAILROAD



30P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

REACH 1

ZONE A5

NOTE:
PROFILE STATIONING IS ALONG LOW POINT IN FLOOD PLAIN WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD. MILE STATION 0.00 EQUALS MILE STATION 0.755 AT CROSS SECTION A ON MAIN CHANNEL.

LAKE VIEW PLACE

ROAD

ELEVATION (FEET NGVD)

3680

3675

3670

3665

0.42 0.44 0.46 0.48 0.50 0.52 0.54 0.56 0.58 0.60 0.62 0.64

STREAM DISTANCE IN MILES ABOVE MOUTH

D

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

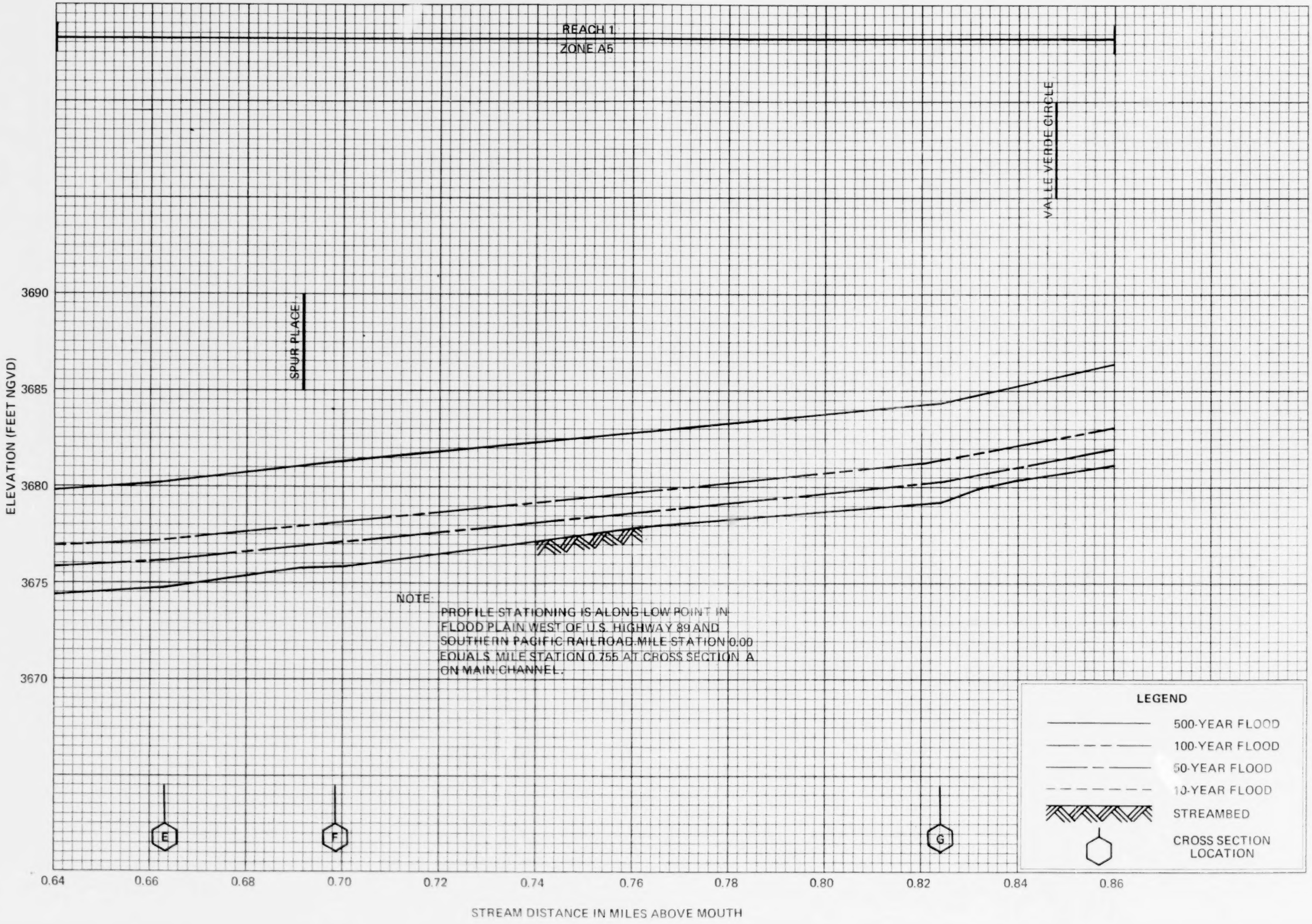
FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

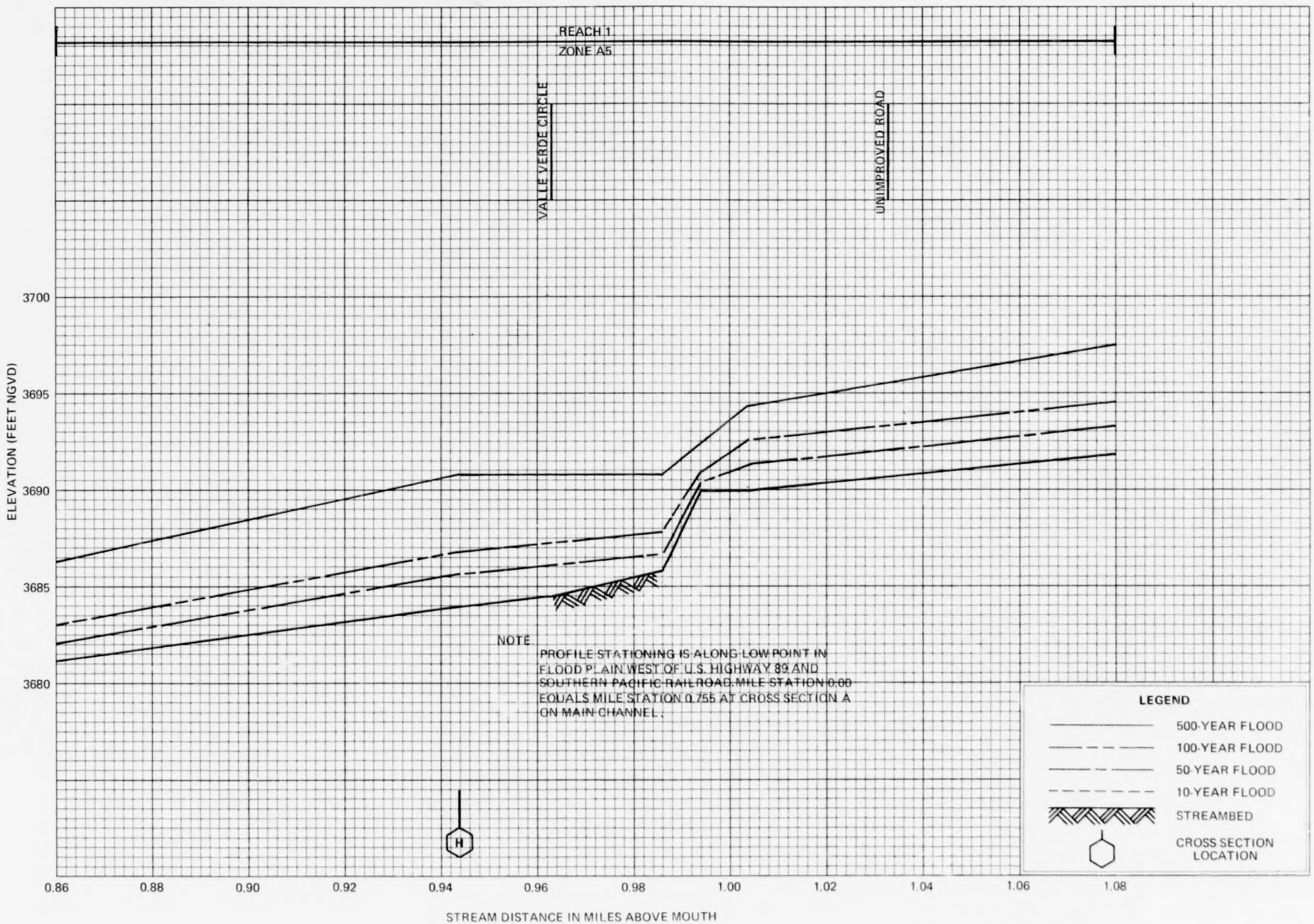


FLOOD PROFILES

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

32P



FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

33P

REACH 1

ZONE A5

UNIMPROVED ROAD

ELEVATION (FEET NGVD)

3710

3705

3700

3695

3690

1.08 1.10 1.12 1.14 1.16 1.18 1.20 1.22 1.24 1.26 1.28 1.30

STREAM DISTANCE IN MILES ABOVE MOUTH

I

J

K

NOTE:

PROFILE STATIONING IS ALONG LOW POINT IN FLOOD PLAIN WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD. MILE STATION 0.00 EQUALS MILE STATION 0.755 AT CROSS SECTION A ON MAIN CHANNEL (SEE PANEL 05P)

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

34P

REACH 1
ZONE A5

ZONE B

ELEVATION (FEET NGVD)

3715
3710
3705
3700
3695

NOTE:
PROFILE STATIONING IS ALONG LOW POINT IN FLOOD PLAIN WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD. MILE STATION 0.00 EQUALS MILE STATION 0.755 AT CROSS SECTION A ON MAIN CHANNEL

L M

LEGEND
- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

1.30 1.32 1.34 1.36 1.38 1.40 1.42 1.44 1.46 1.48 1.50 1.52

STREAM DISTANCE IN MILES ABOVE MOUTH

FLOOD PROFILES

NOGALES WASH FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

35P

ZONE B

LIMIT OF DETAILED STUDY

ELEVATION (FEET NGVD)

3715

3710

3705

3700

3695

3690

1.52 1.54 1.56 1.58 1.60

STREAM DISTANCE IN MILES ABOVE MOUTH

NOTE:
PROFILE STATIONING IS ALONG LOW POINT IN FLOOD PLAIN WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD MILE STATION 0.00 EQUALS MILE STATION 0.755 AT CROSS SECTION A ON MAIN CHANNEL

N

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

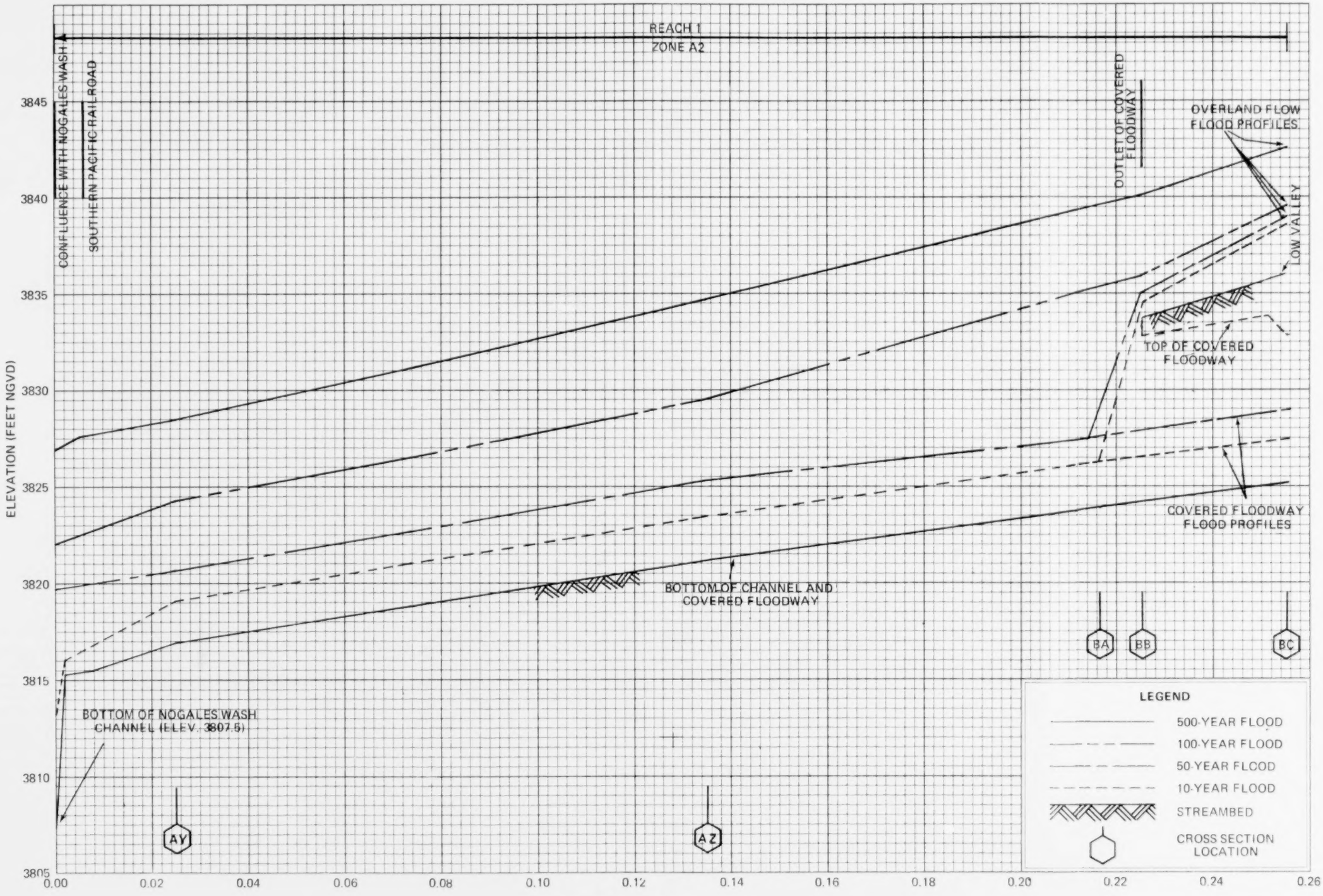
FLOOD PROFILES

NOGALES WASH-FLOW WEST OF U.S. HIGHWAY 89 AND SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

36P



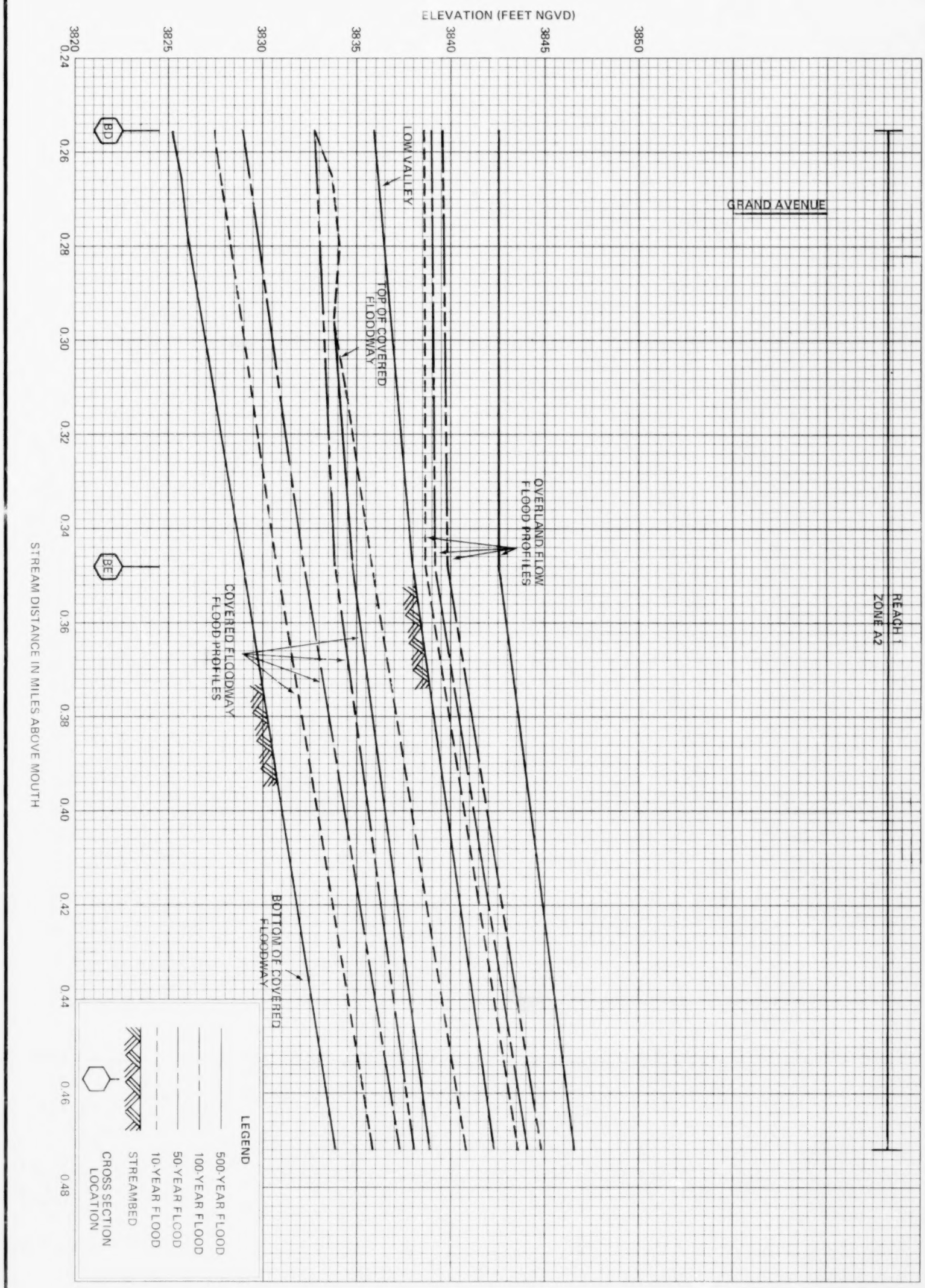
FLOOD PROFILES

ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

37P



38P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

FLOOD PROFILES

ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD

REACH 1
ZONE A2

WALNUT STREET

ELM STREET

CONFLUENCE OF OVERLAND FLOWS
FROM EAST SIDE OF SOUTHERN PACIFIC RAILROAD
(SEE PANEL 27P)

OVERLAND FLOW
FLOOD PROFILES

TOP OF COVERED
FLOODWAY

LOW VALLEY

BOTTOM OF COVERED
FLOODWAY

COVERED FLOODWAY
FLOOD PROFILES

ELEVATION (FEET NGVD)

3860
3855
3850
3845
3840
3835
3830

BF
BG
BH

0.46 0.48 0.50 0.52 0.54 0.56 0.58 0.60 0.62 0.64 0.66 0.68 0.70

STREAM DISTANCE IN MILES ABOVE MOUTH

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

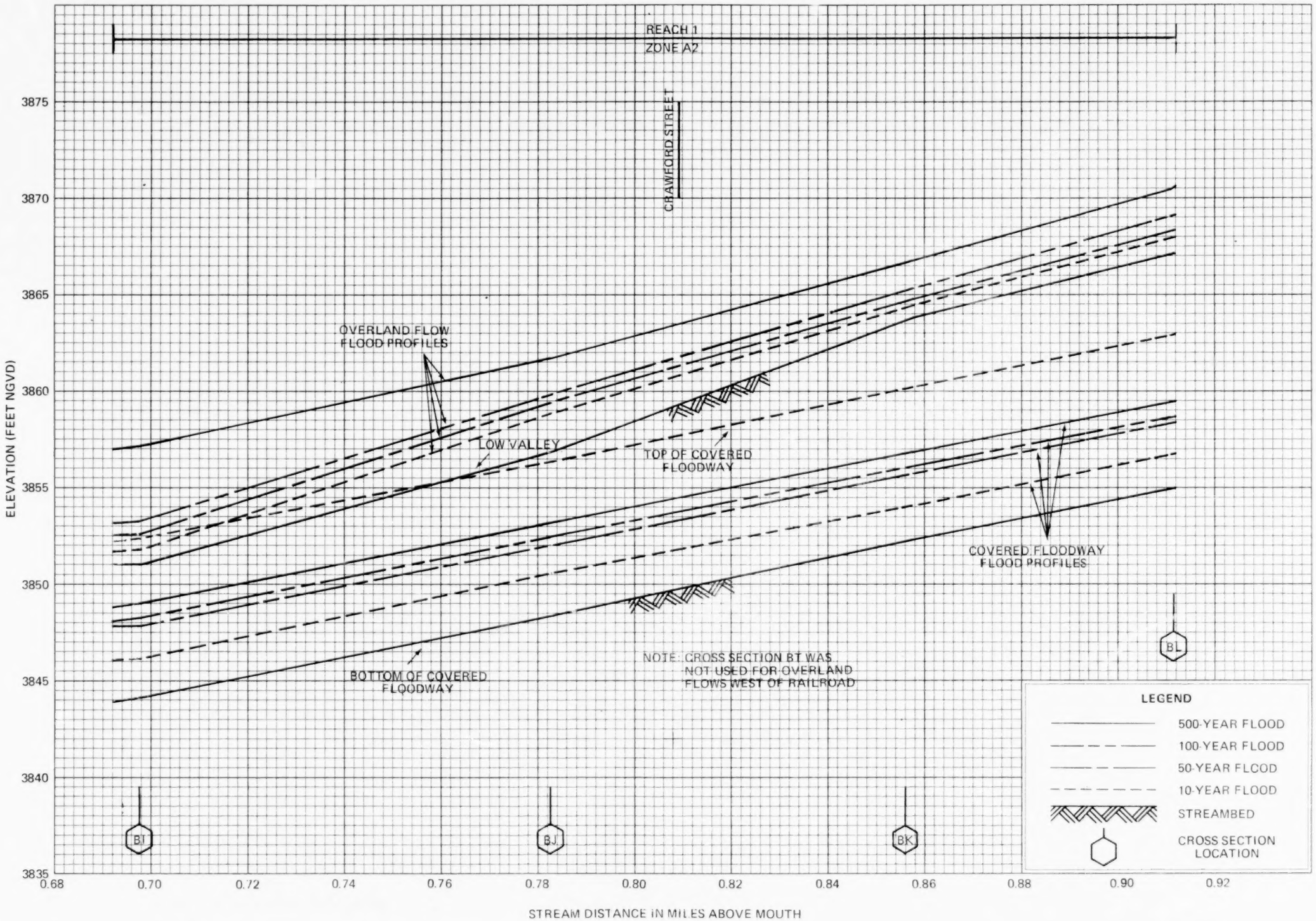
FLOOD PROFILES

ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

39P

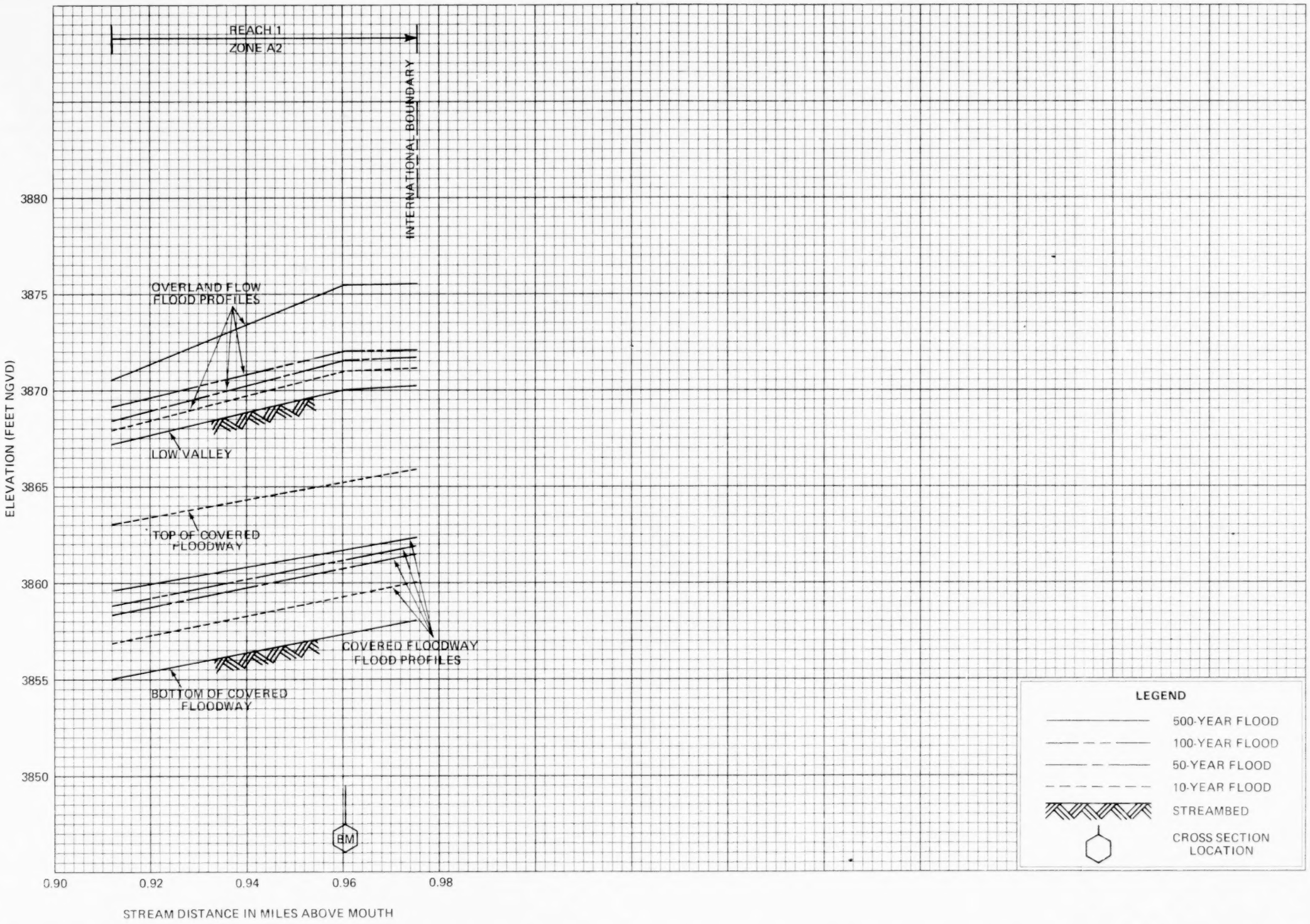


FLOOD PROFILES

ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)



FLOOD PROFILES

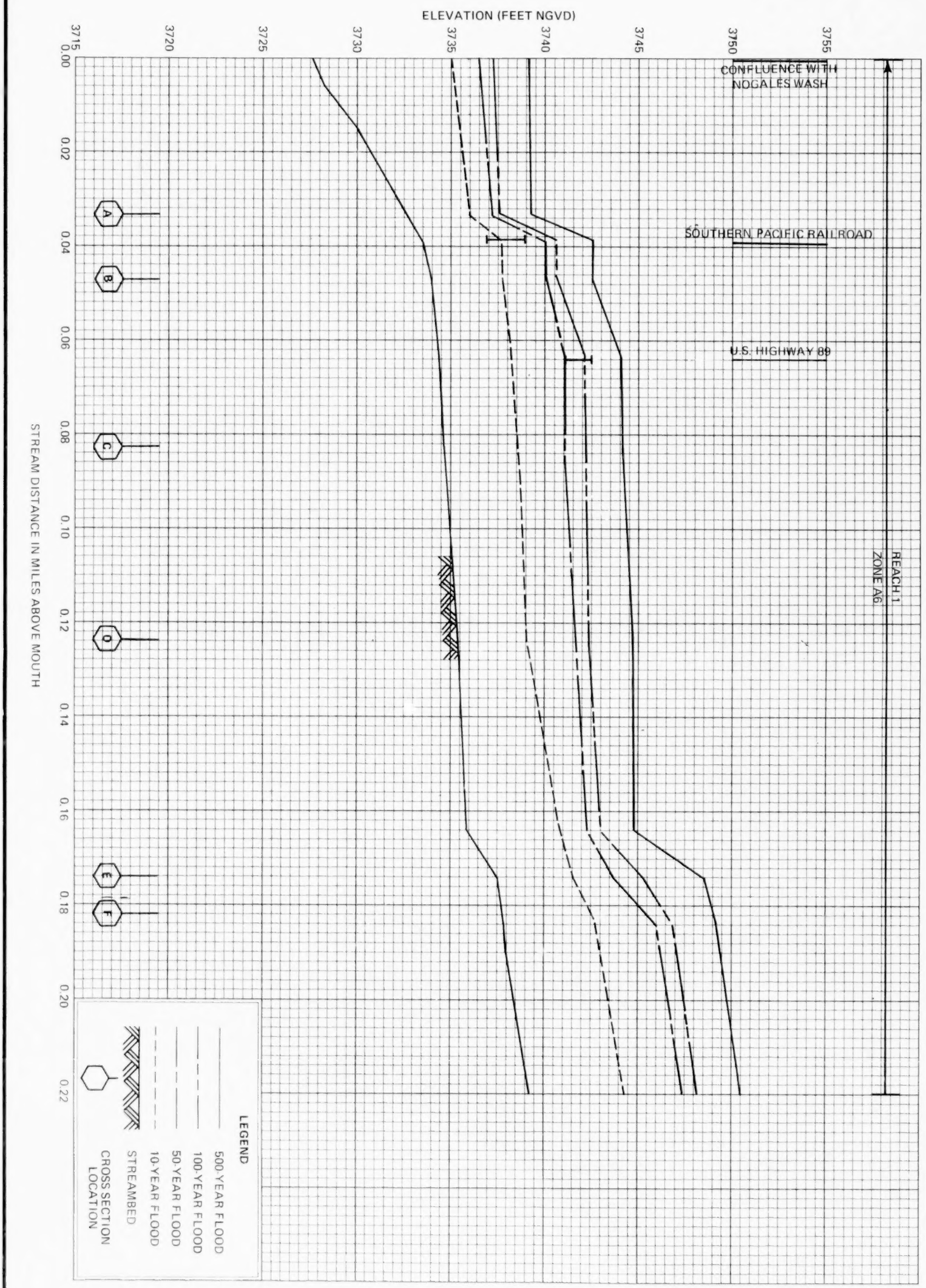
ARROYO BOULEVARD CHANNEL AND COVERED FLOODWAY AND OVERLAND FLOWS WEST OF SOUTHERN PACIFIC RAILROAD

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

41P



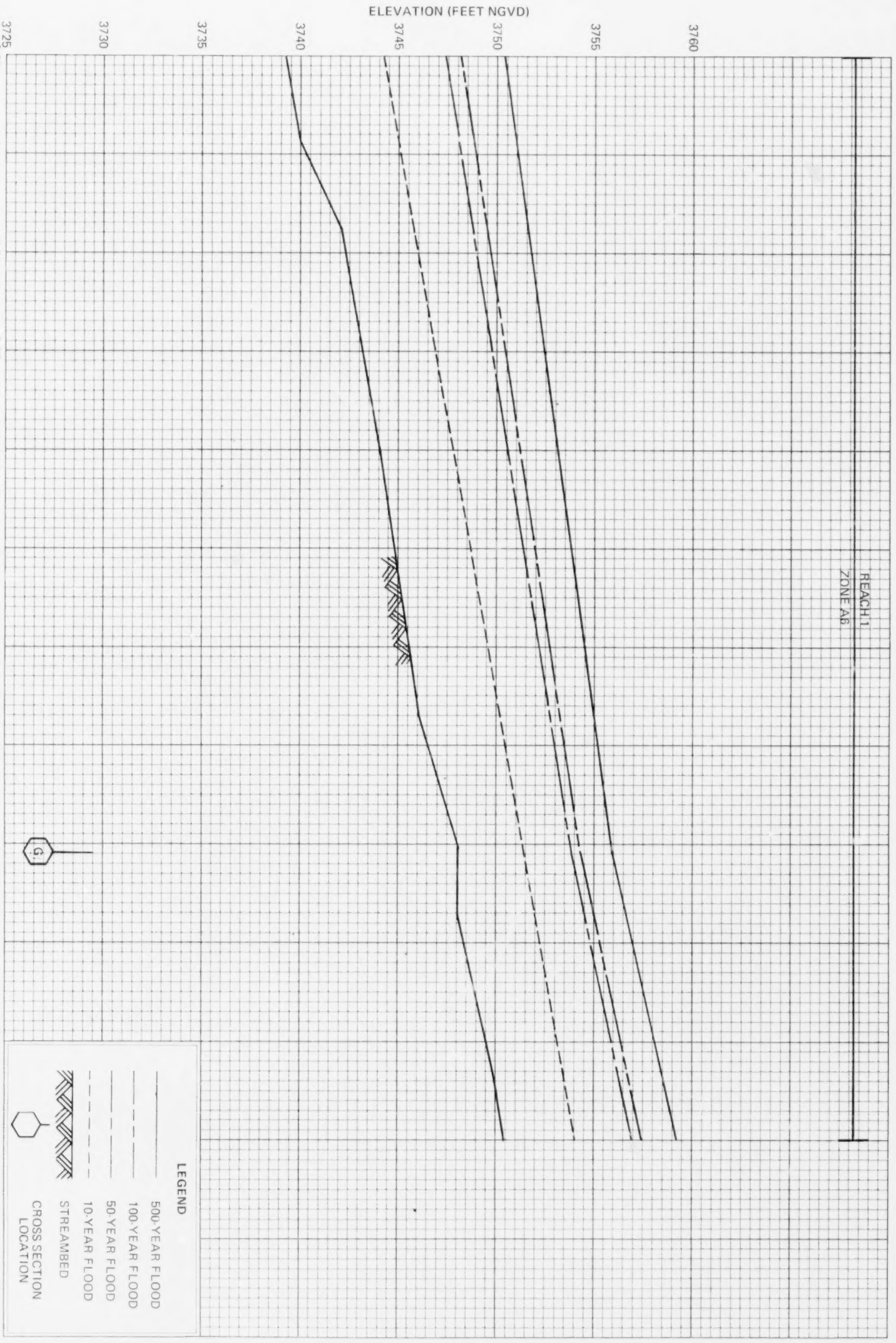
42P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

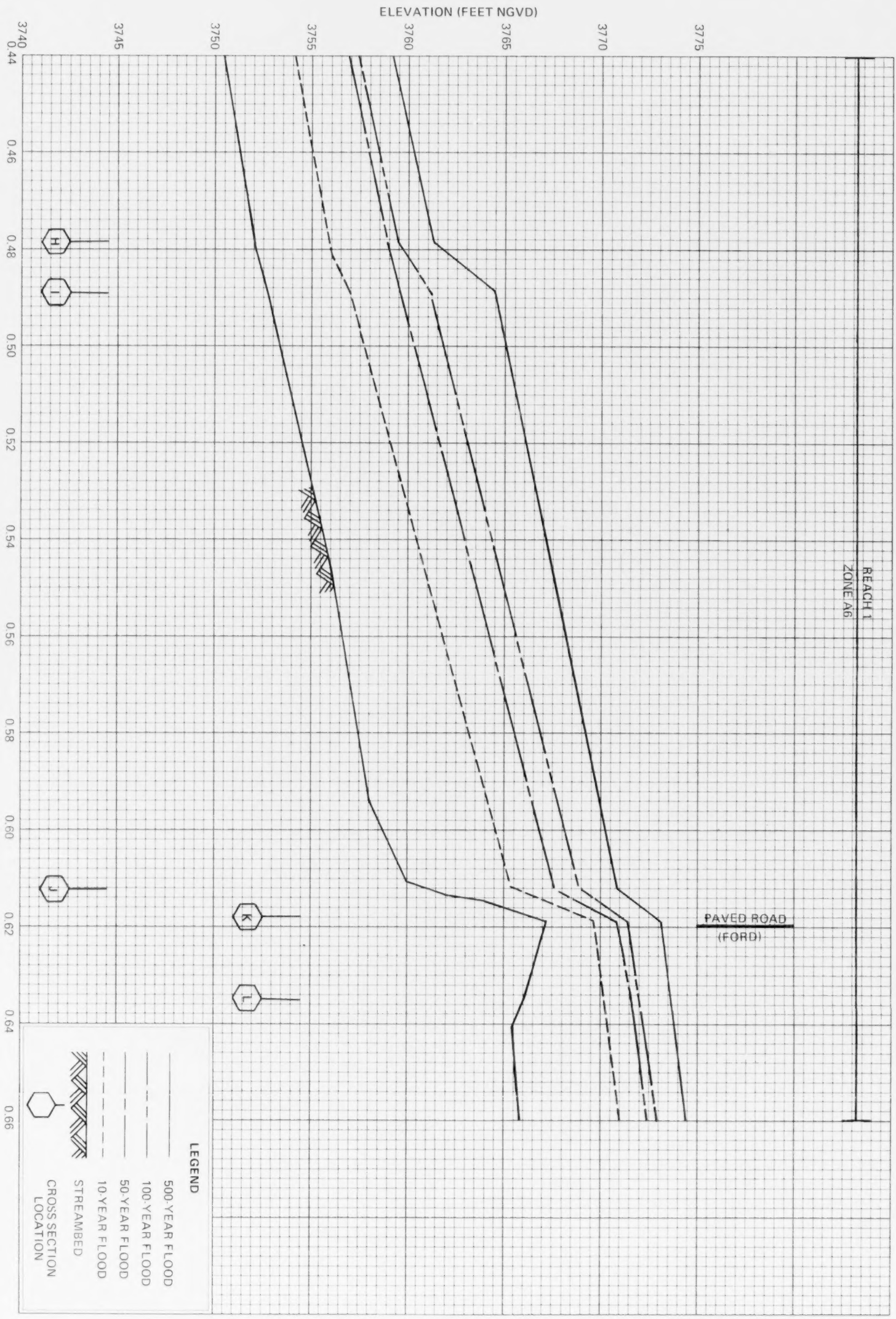


FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



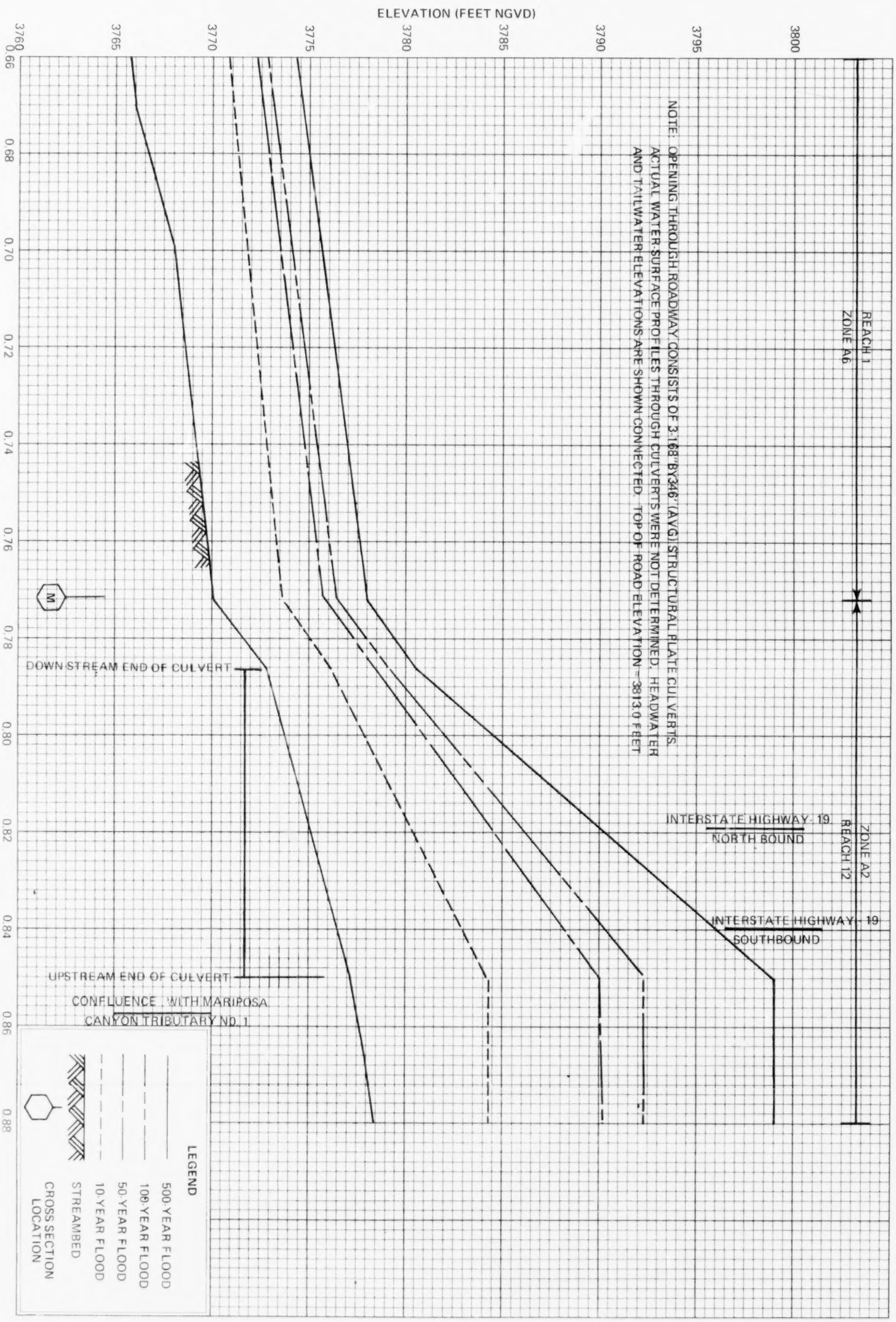
44P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



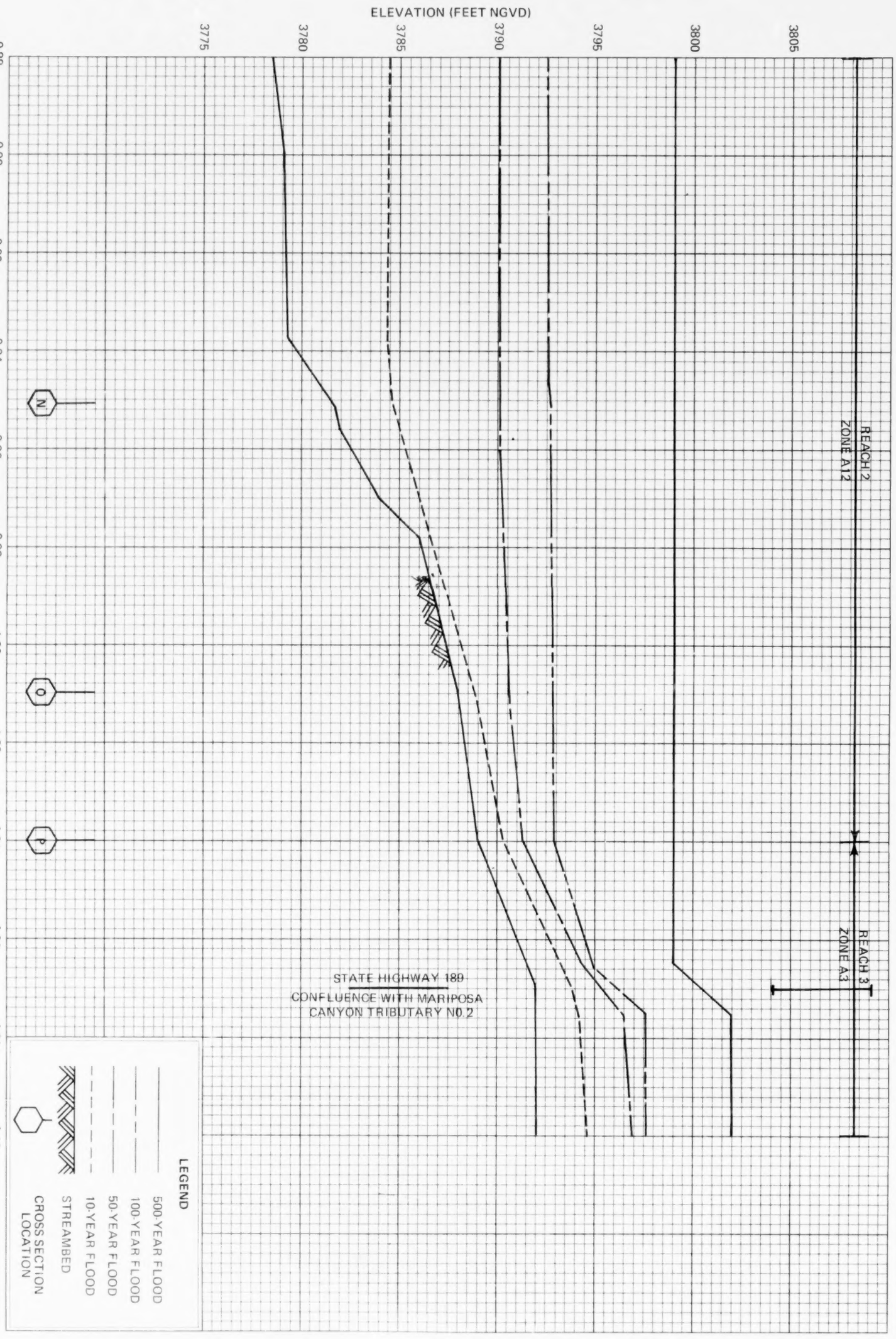
45P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



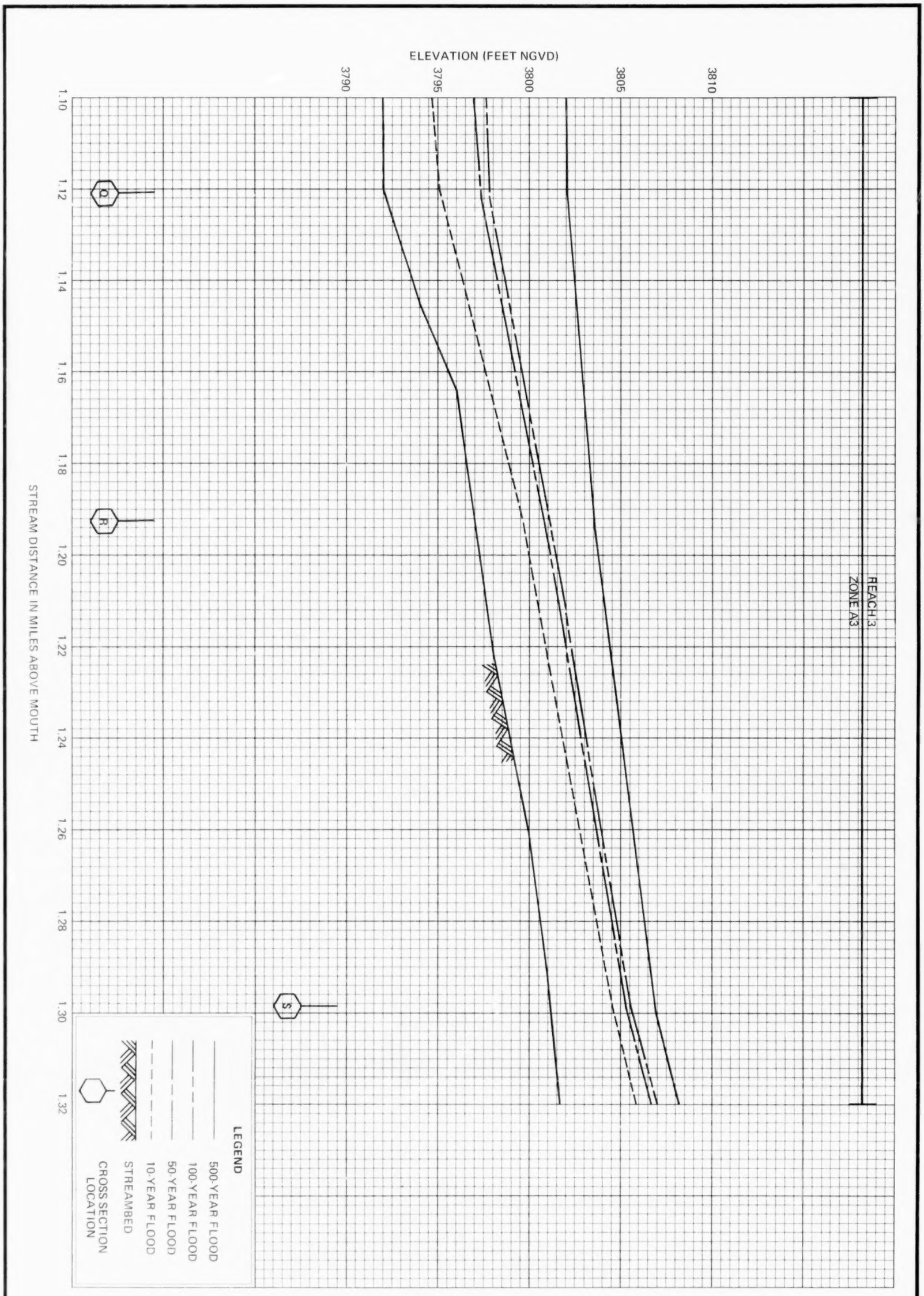
46P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



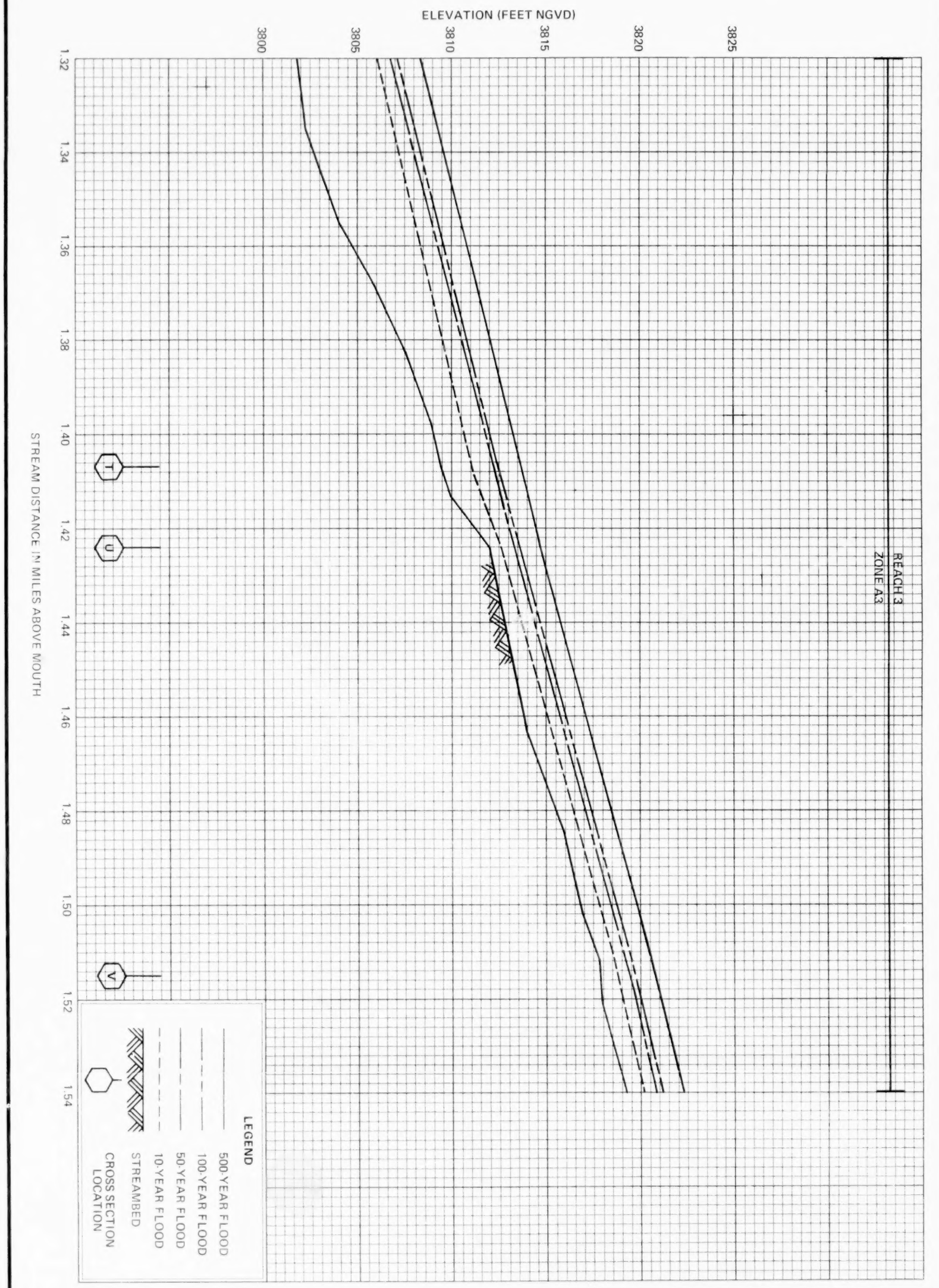
47P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



48P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

REACH 3
ZONE A3

ELEVATION (FEET NGVD)

3835
3830
3825
3820
3815

1.54 1.56 1.58 1.60 1.62 1.64 1.66 1.68 1.70 1.72 1.74 1.76

STREAM DISTANCE IN MILES ABOVE MOUTH

W
X

LEGEND

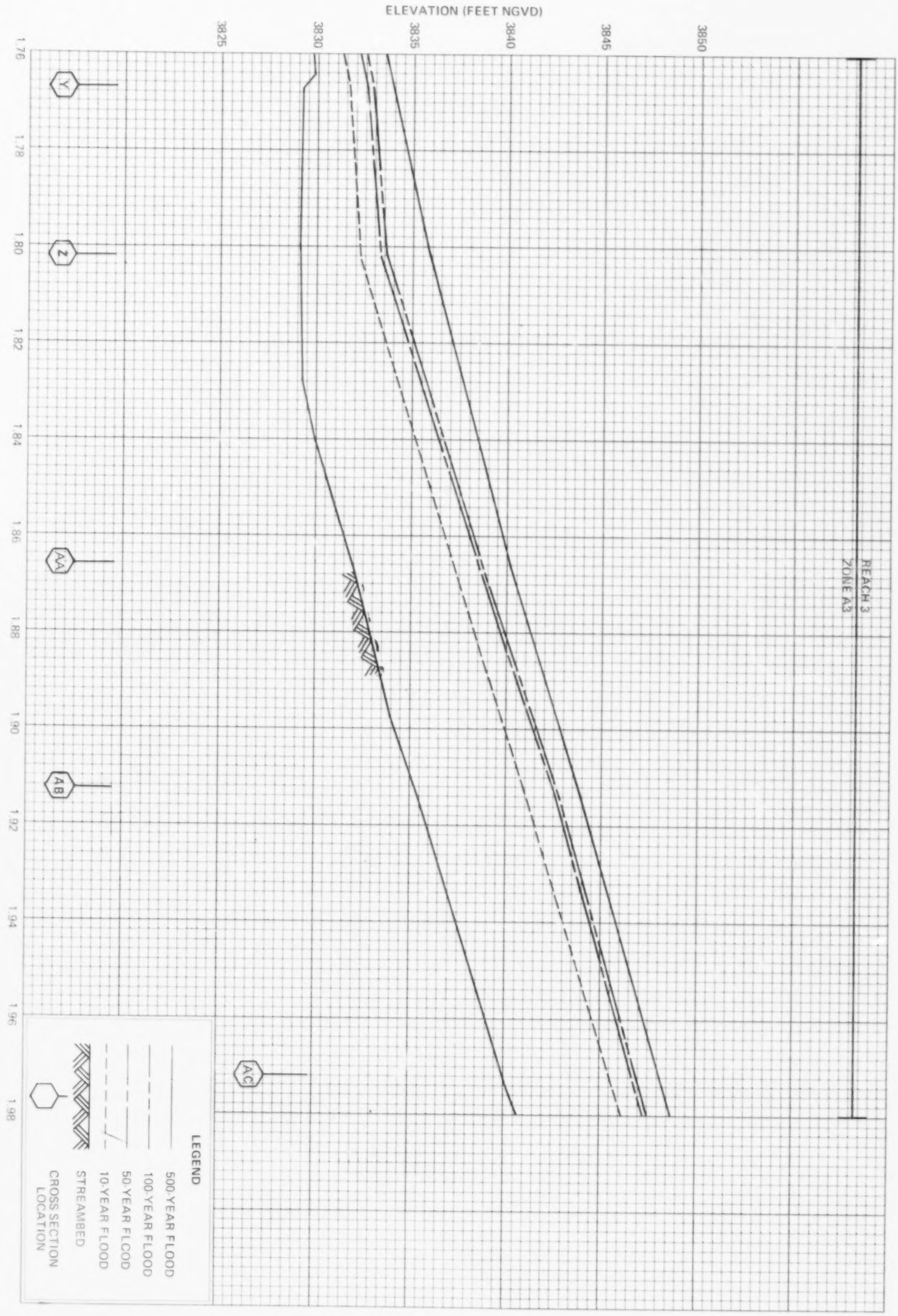
- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)



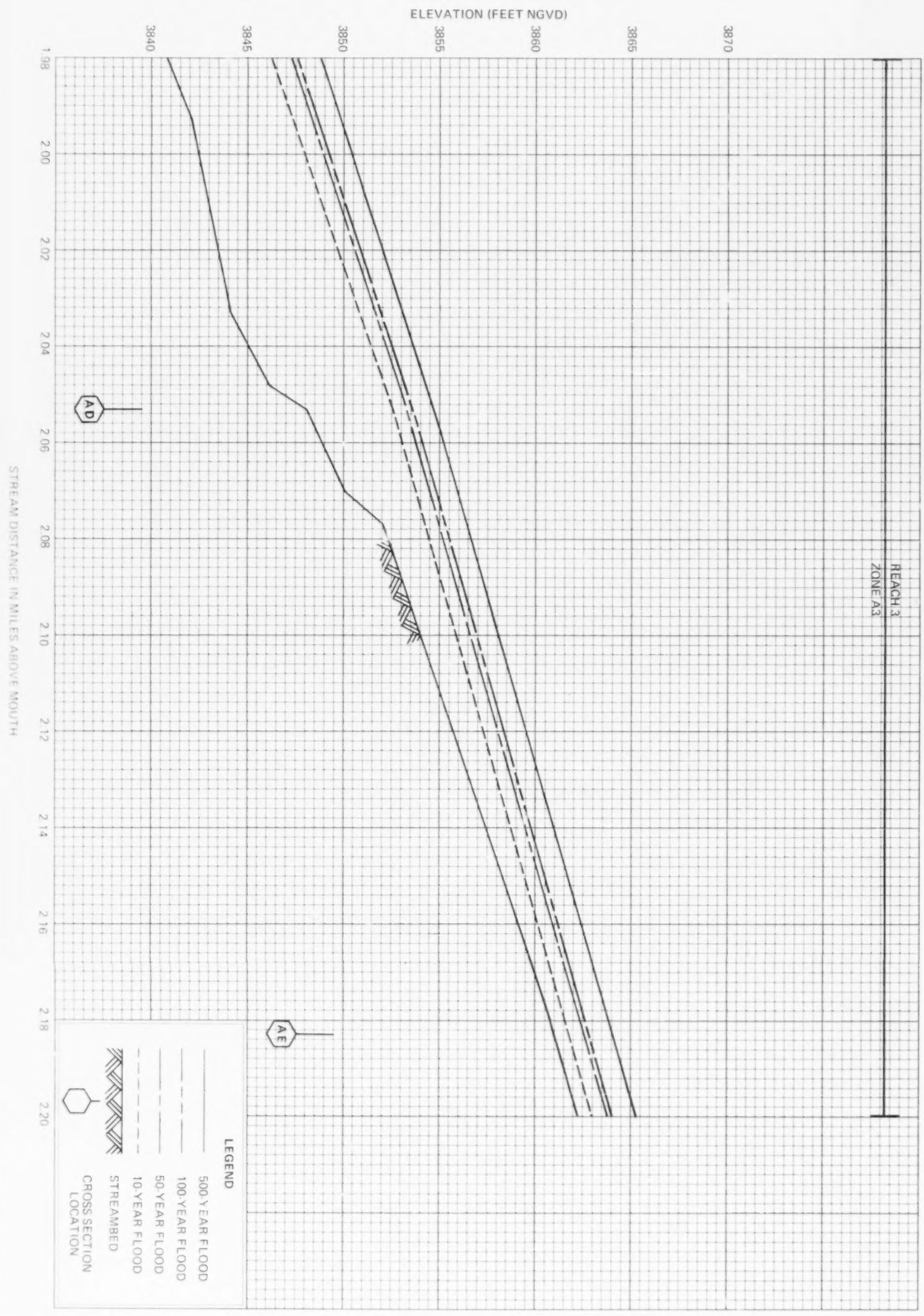
50P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



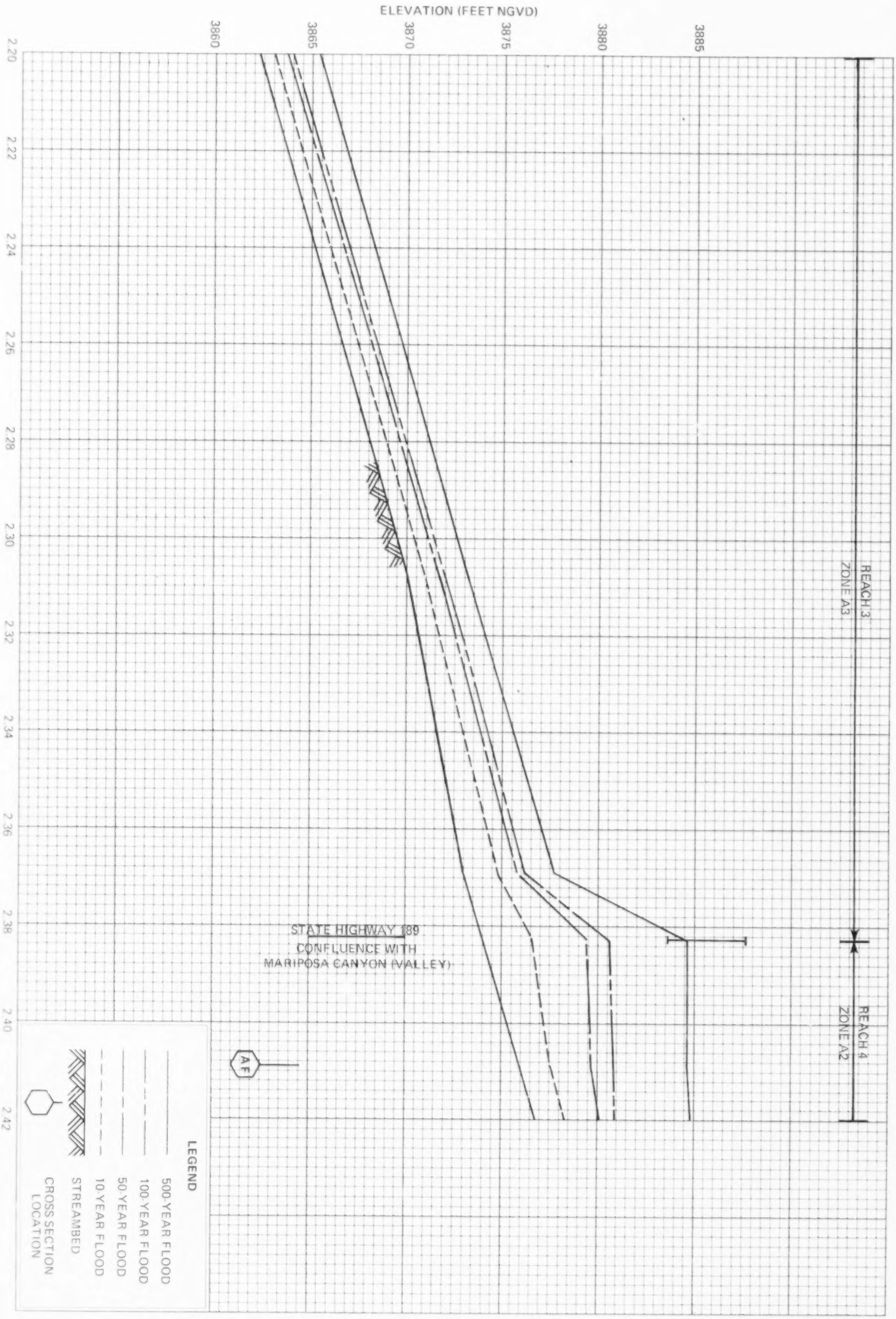
51P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



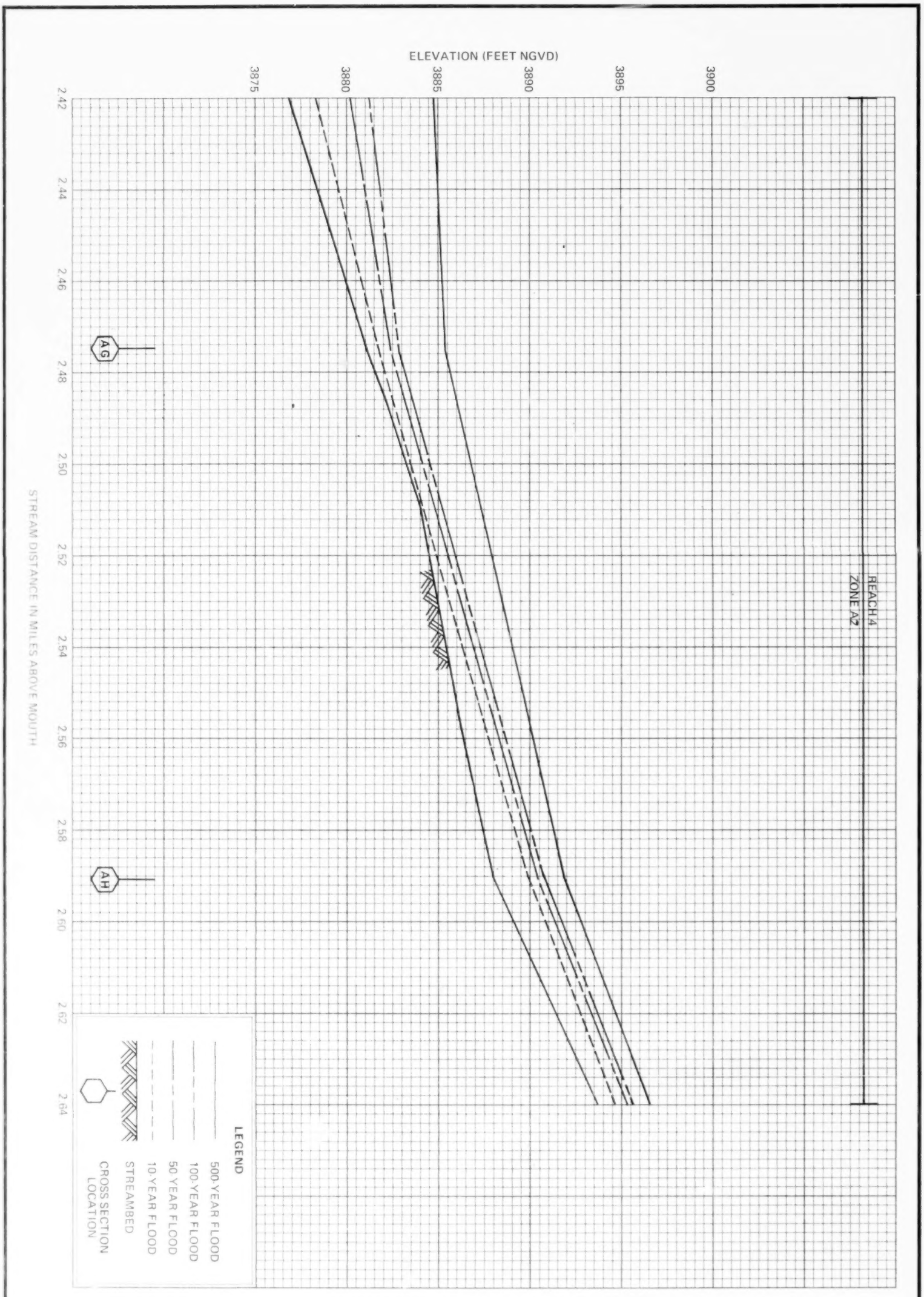
52P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



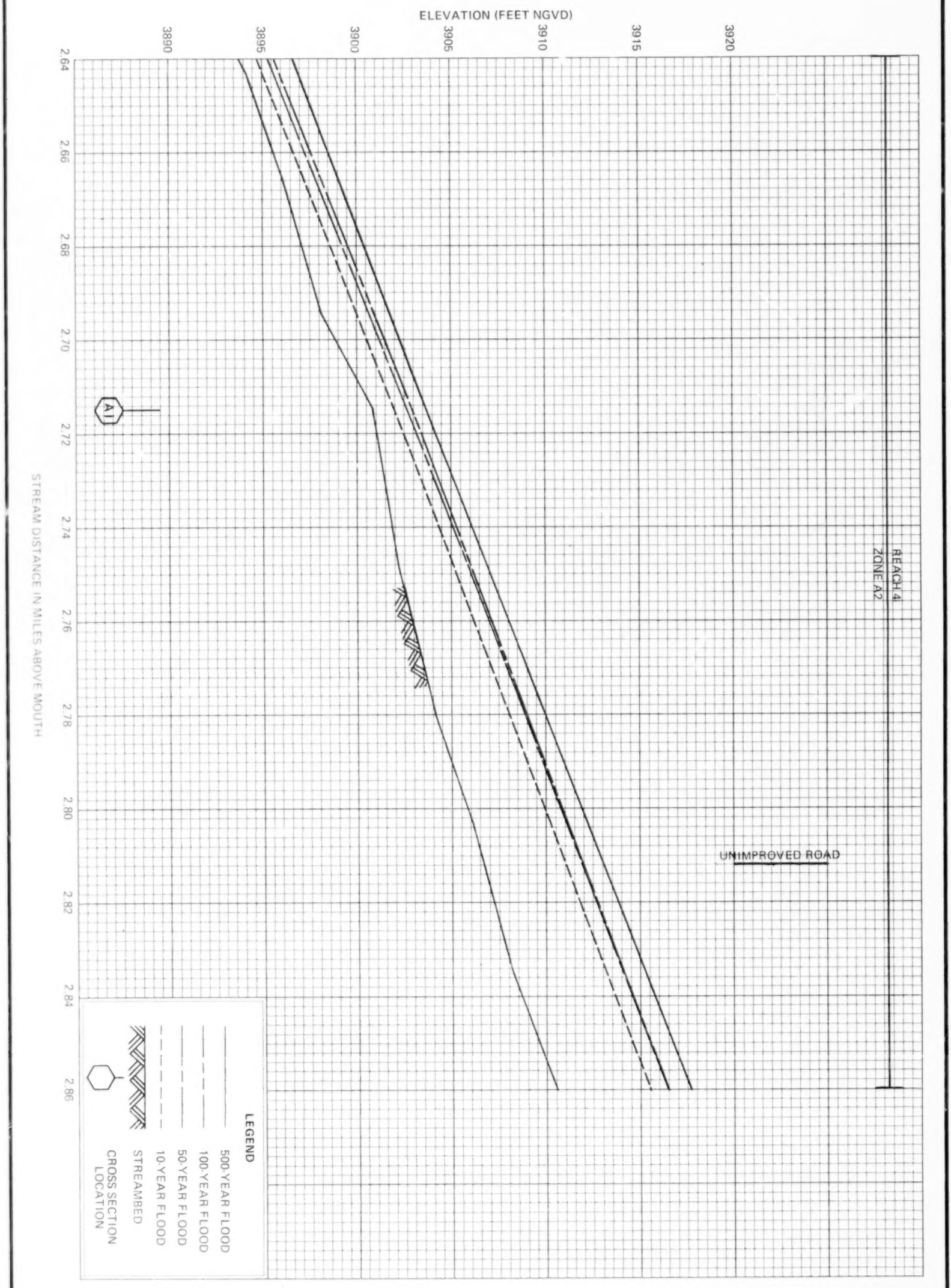
53P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



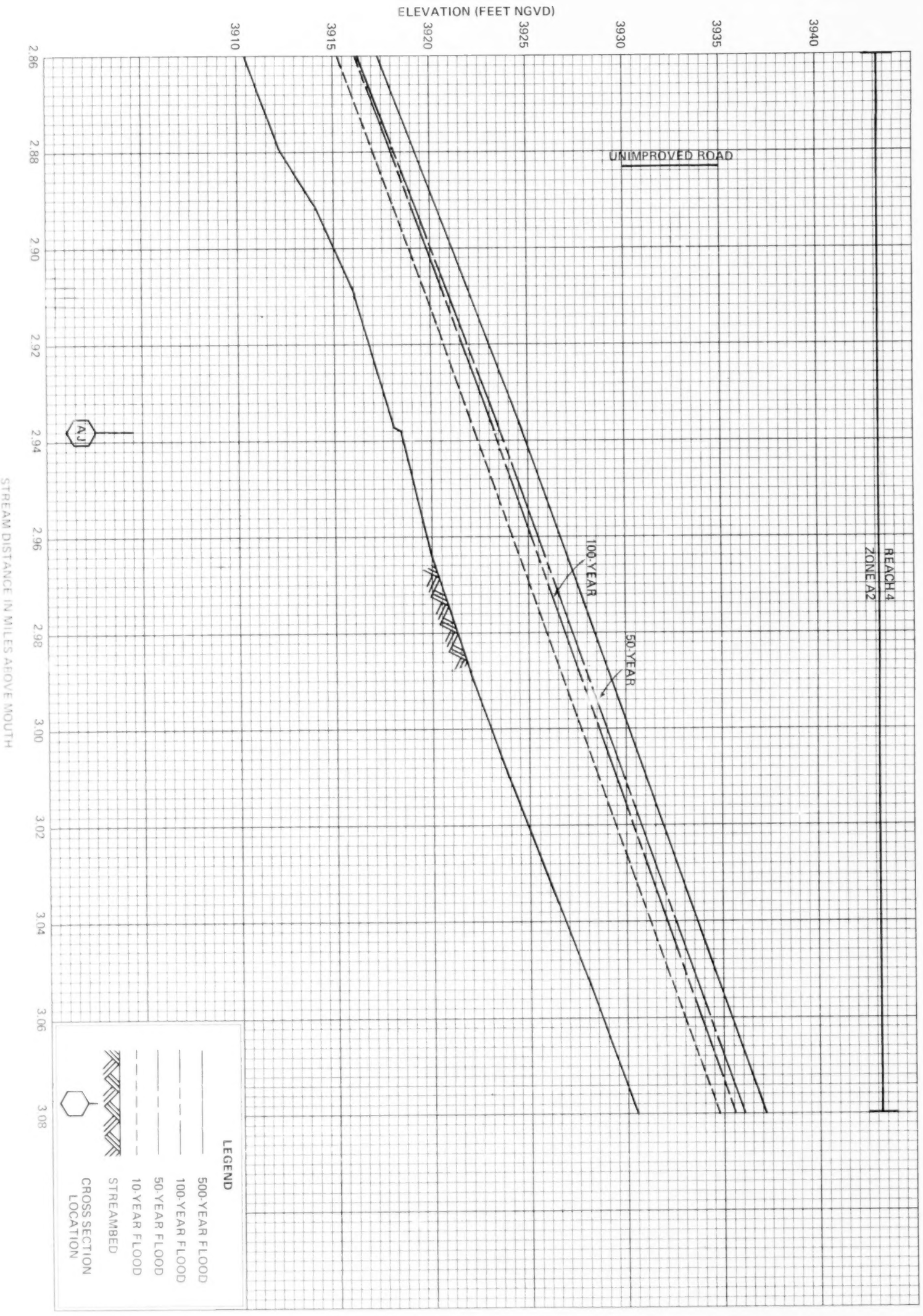
54P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)



55P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

REACH 4
ZONE A2

50-YEAR
100-YEAR

ELEVATION (FEET NGVD)

3960
3955
3950
3945
3940
3935
3930

AK

3.08 3.10 3.12 3.14 3.16 3.18 3.20 3.22 3.24 3.26 3.28 3.30

STREAM DISTANCE IN MILES ABOVE MOUTH

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

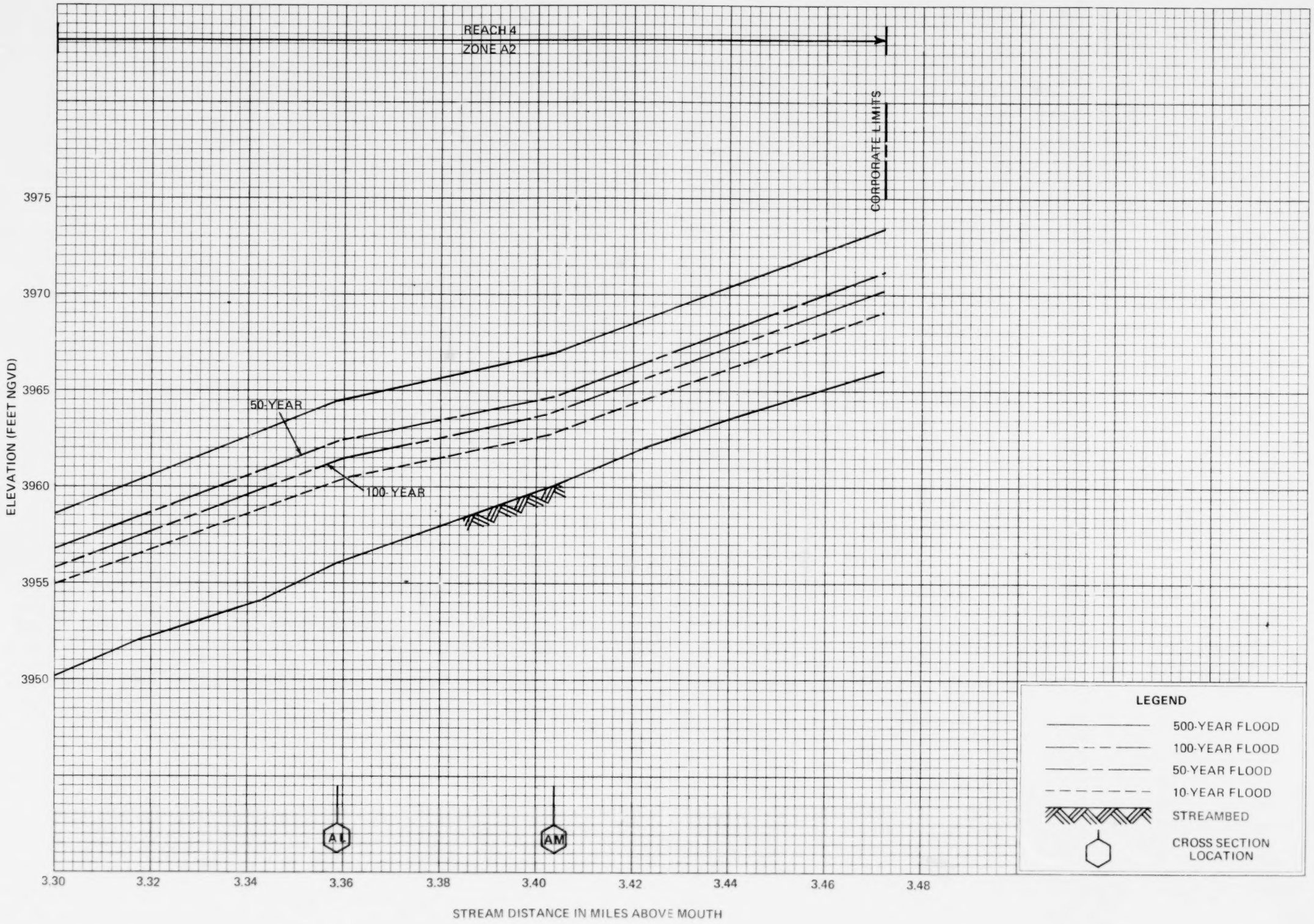
FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

56P



FLOOD PROFILES

MARIPOSA CANYON (CHANNEL)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

57P

REACH 1
ZONE A2

STATE HIGHWAY 189

MARIPOSA ROAD

ELEVATION (FEET NGVD)

3895
3890
3885
3880
3875
3870

NOTE:
PROFILE STATIONING IS ALONG LOW POINT IN NORTH FLOOD PLAIN. MILE STATION 0.00 EQUALS MILE STATION 2.383 AT STATE HIGHWAY 189 (SEE PROFILE 52P)

AF
AG
AH

LEGEND
- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAMBED
- CROSS SECTION LOCATION

0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22

STREAM DISTANCE IN MILES ABOVE MOUTH

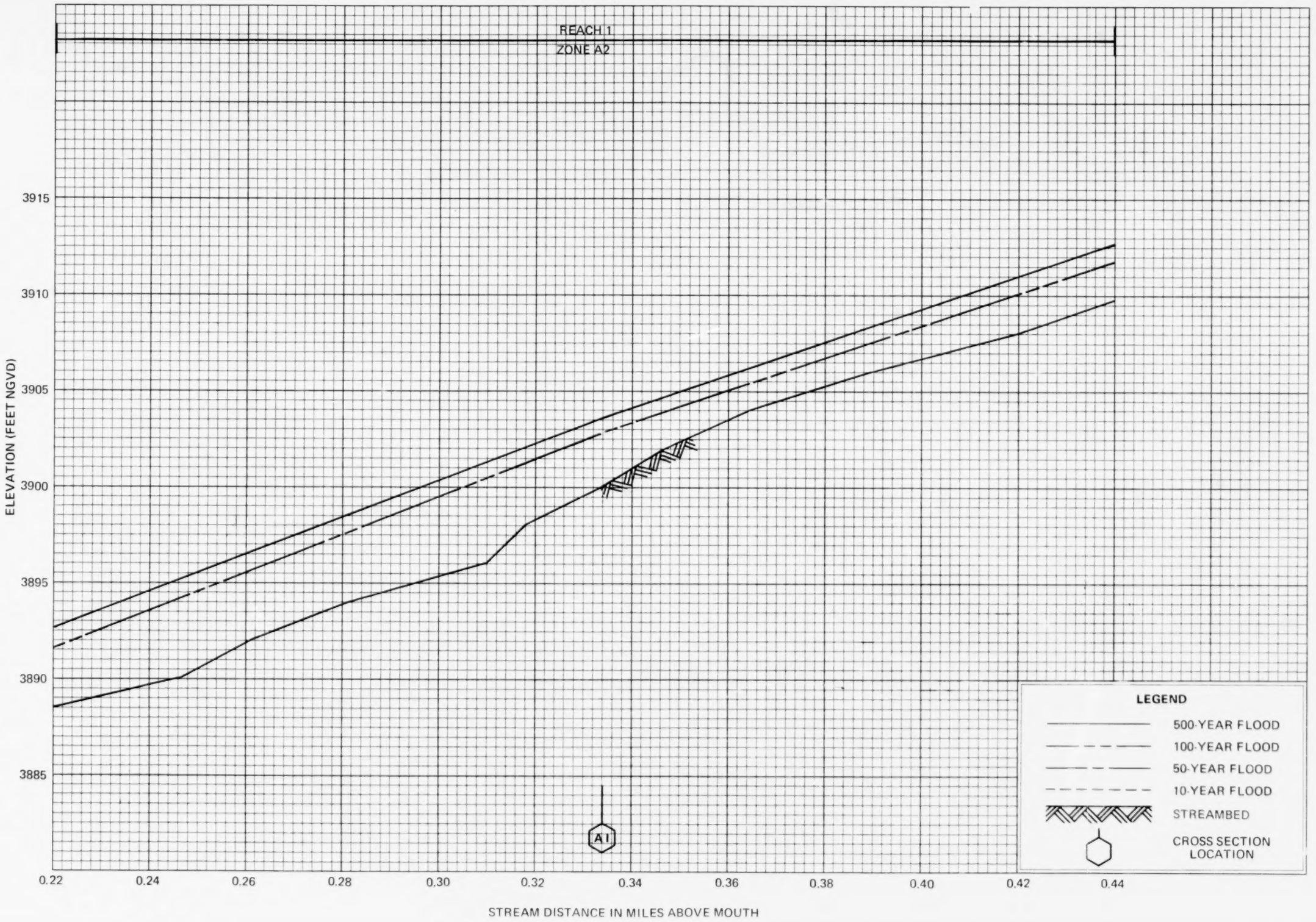
FLOOD PROFILES

MARIPOSA CANYON (VALLEY)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

58P



FLOOD PROFILES

MARIPOSA CANYON (VALLEY)

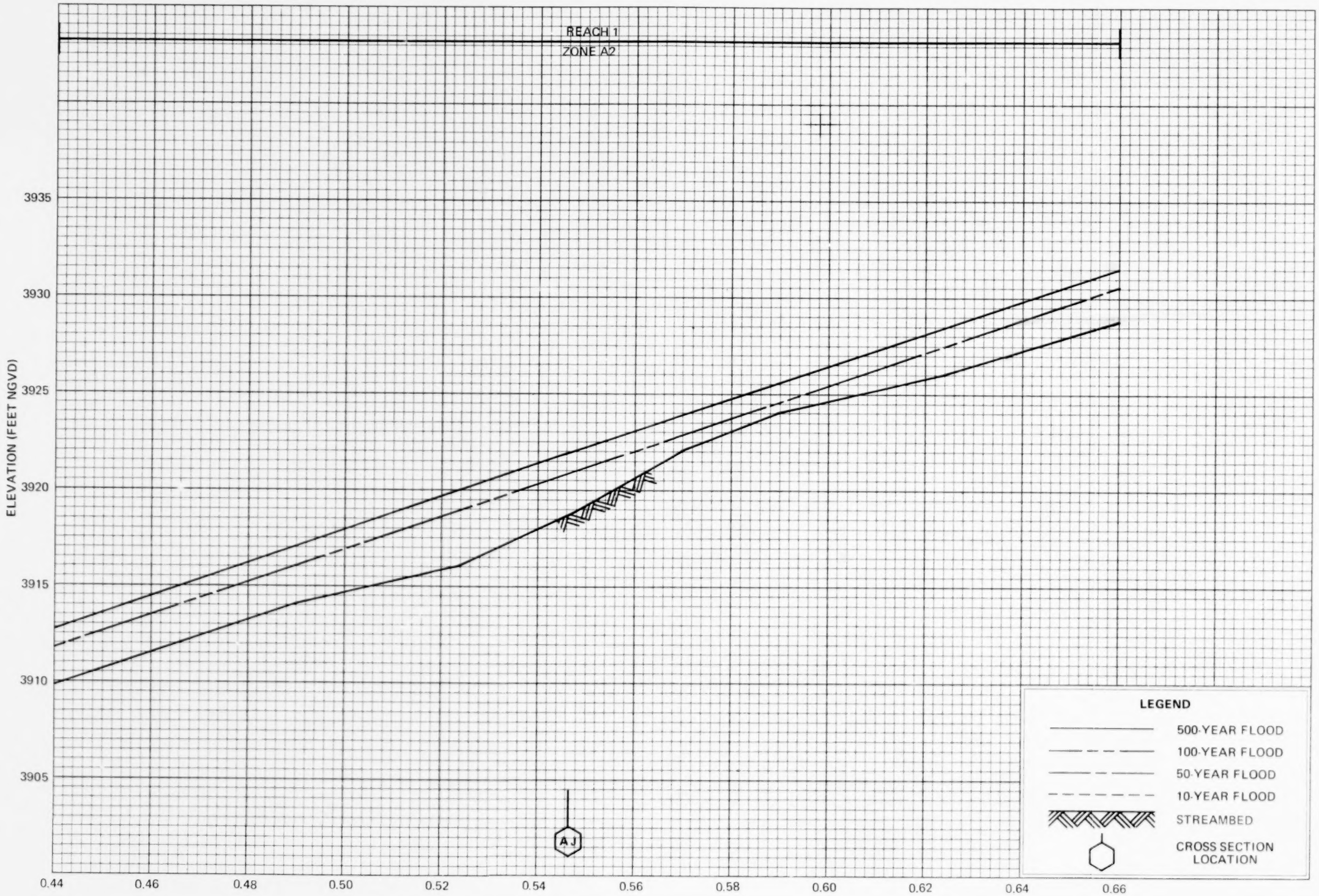
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

59P

REACH 1

ZONE A2



STREAM DISTANCE IN MILES ABOVE MOUTH

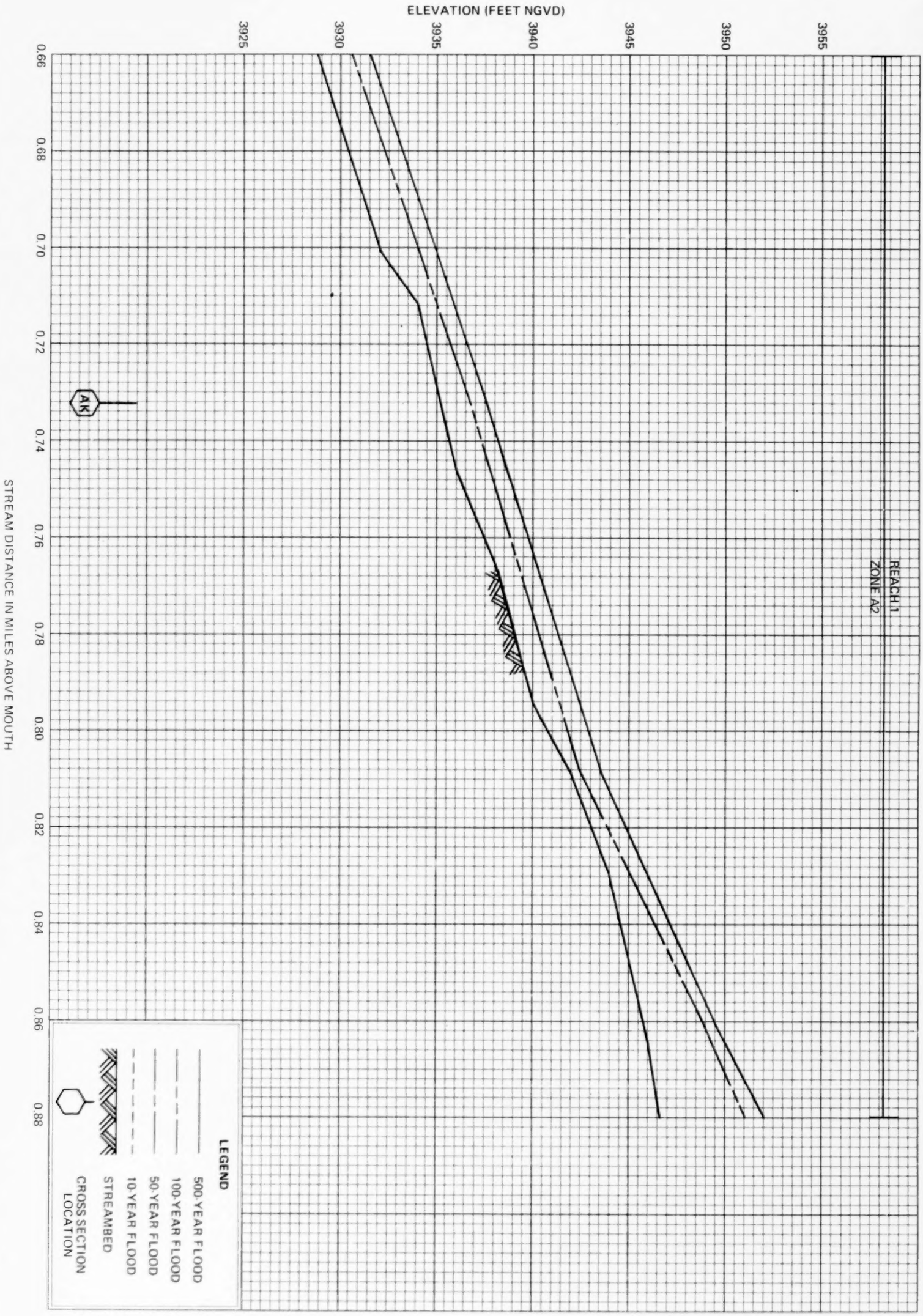
FLOOD PROFILES

MARIPOSA CANYON (VALLEY)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

60P



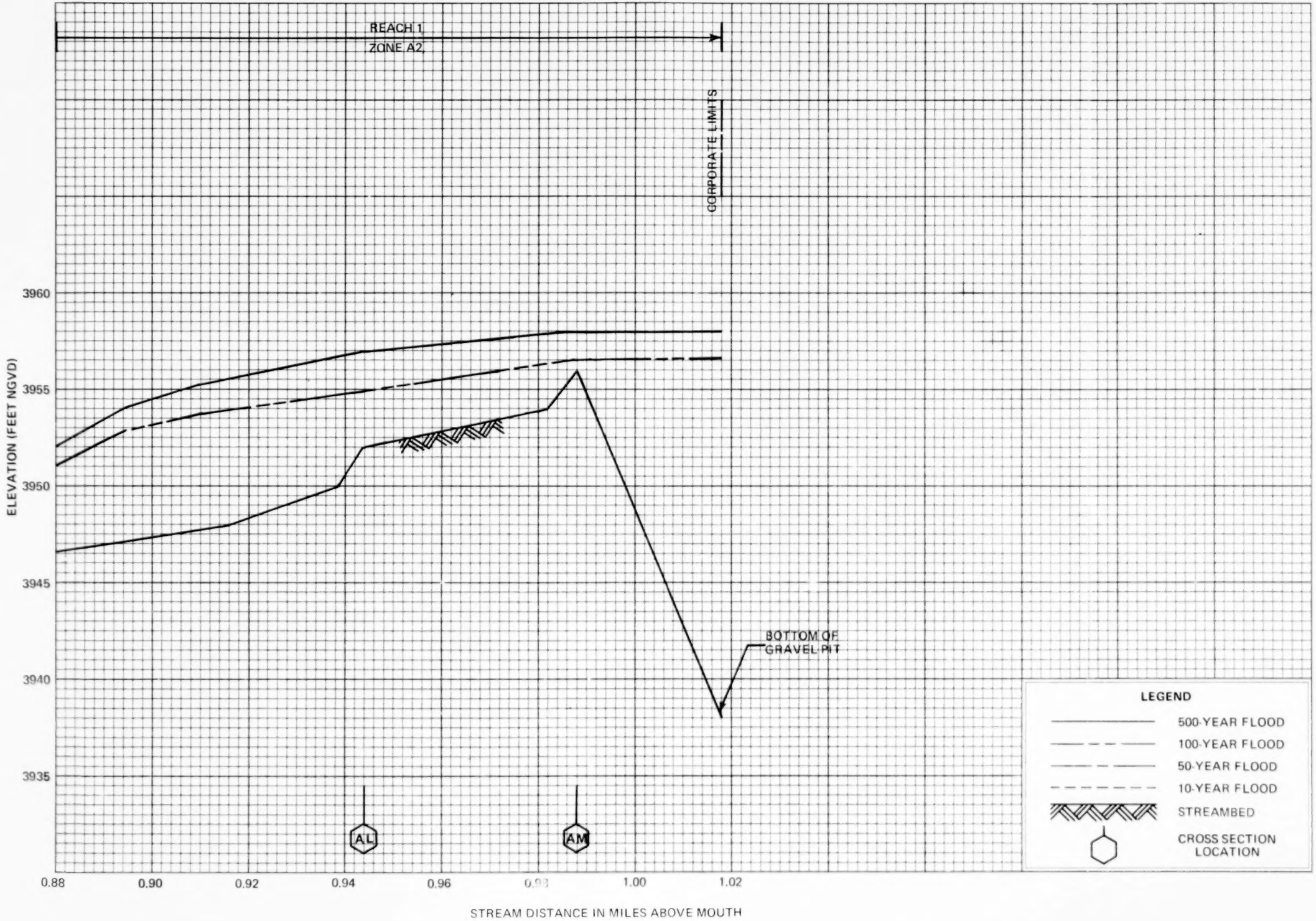
61P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
[SANTA CRUZ CO.]

FLOOD PROFILES

MARIPOSA CANYON [VALLEY]



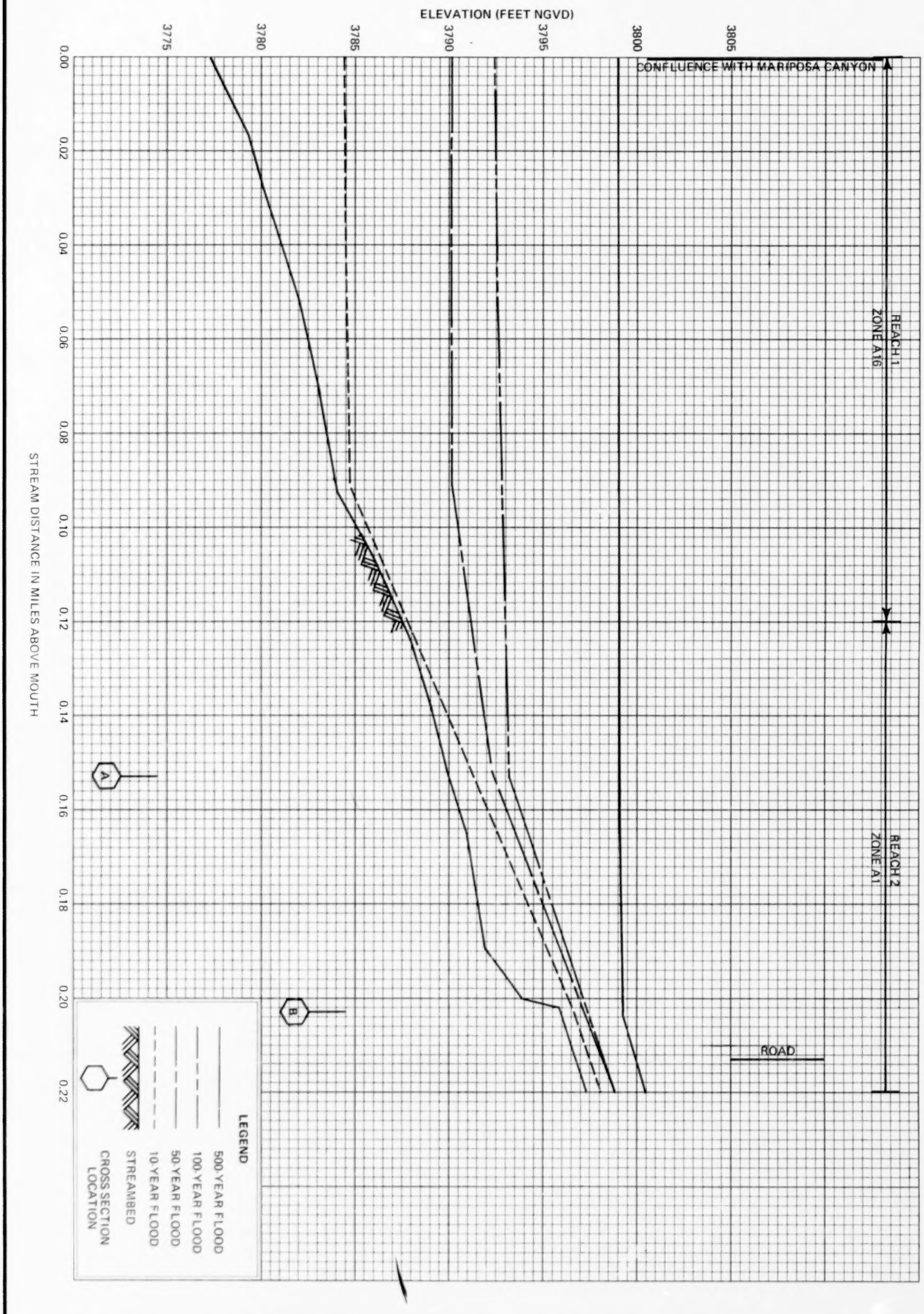
FLOOD PROFILES

MARIPOSA CANYON (VALLEY)

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

62P



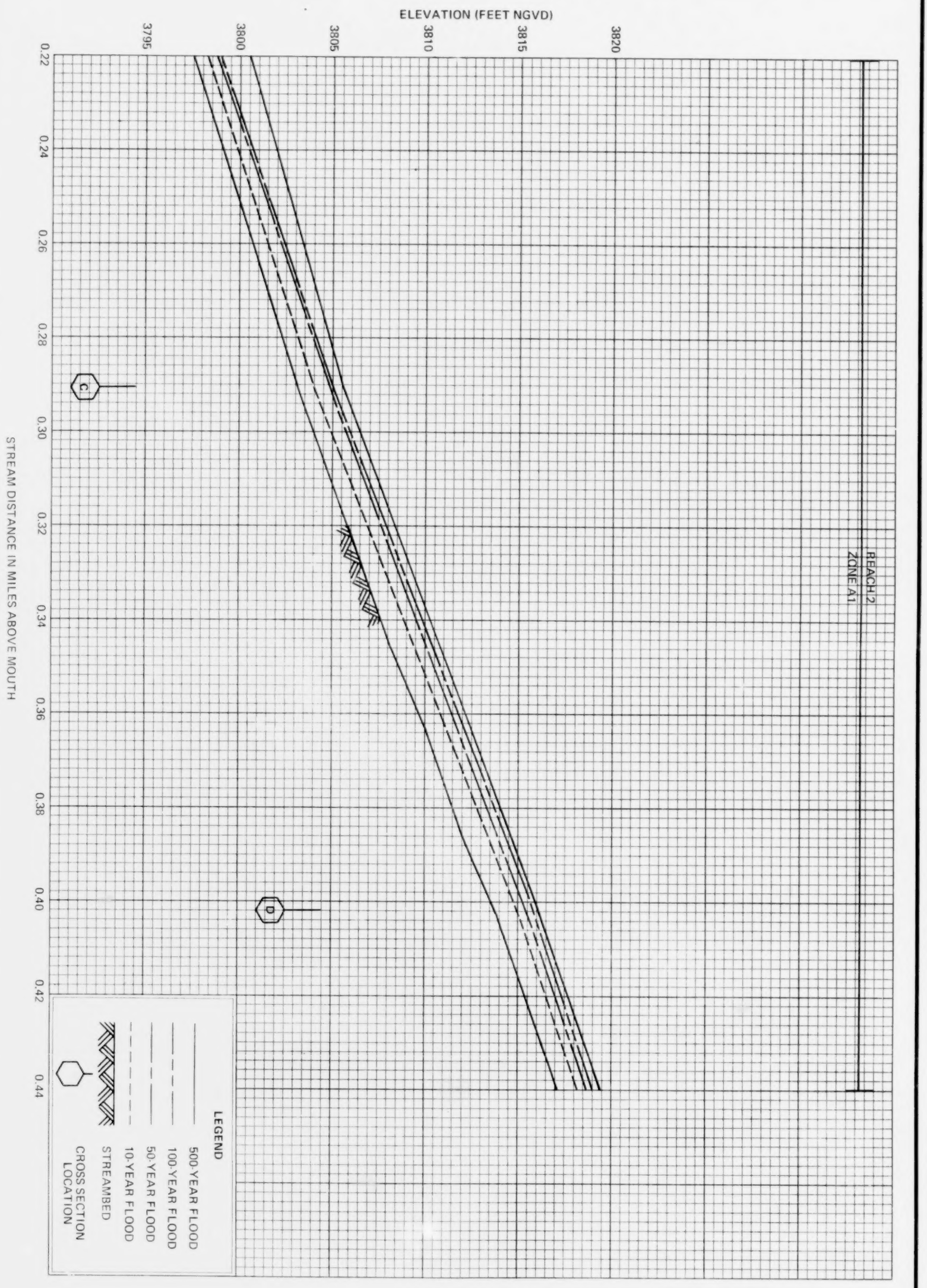
63P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 1



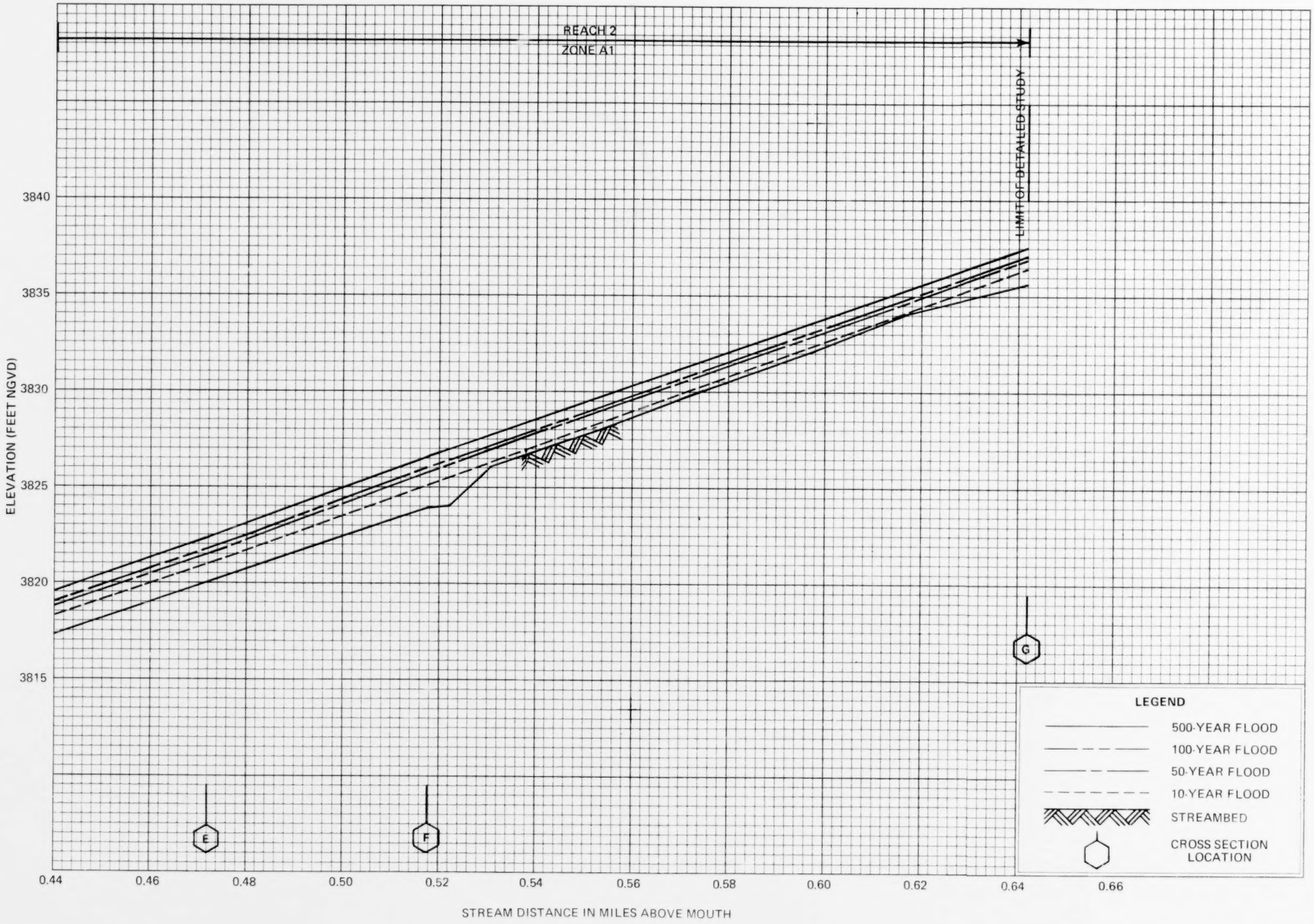
64P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 1



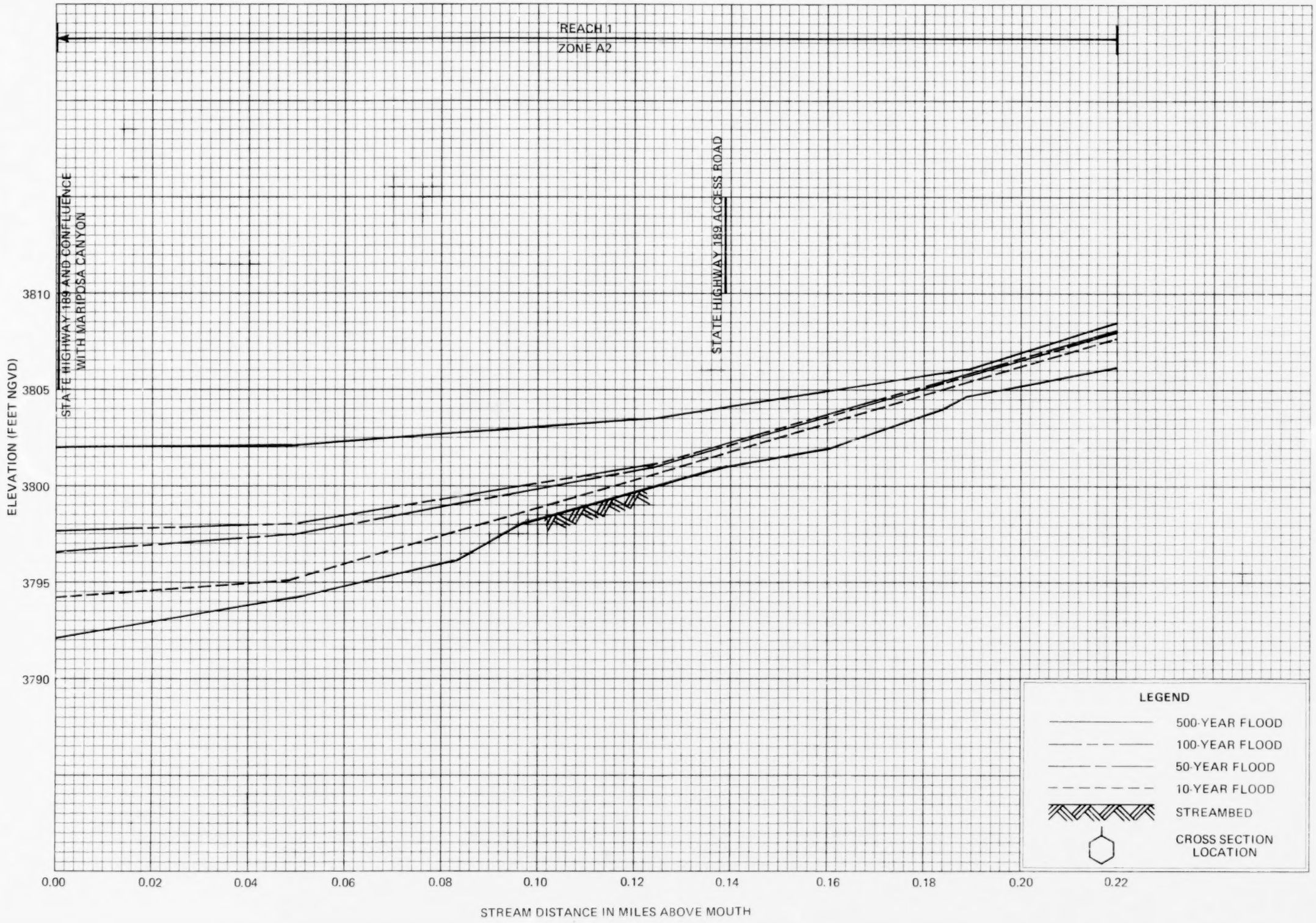
FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

65P



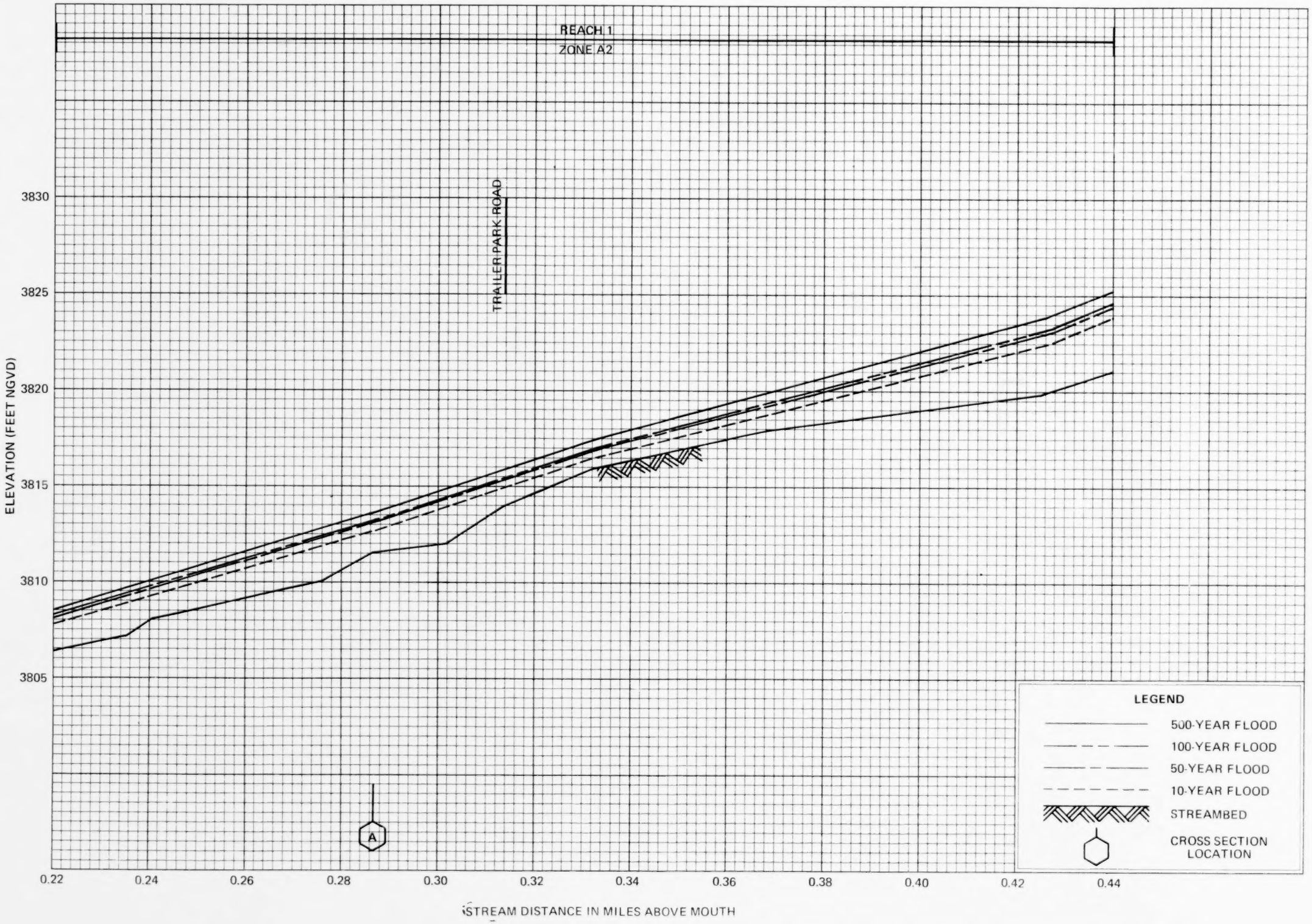
FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

66P



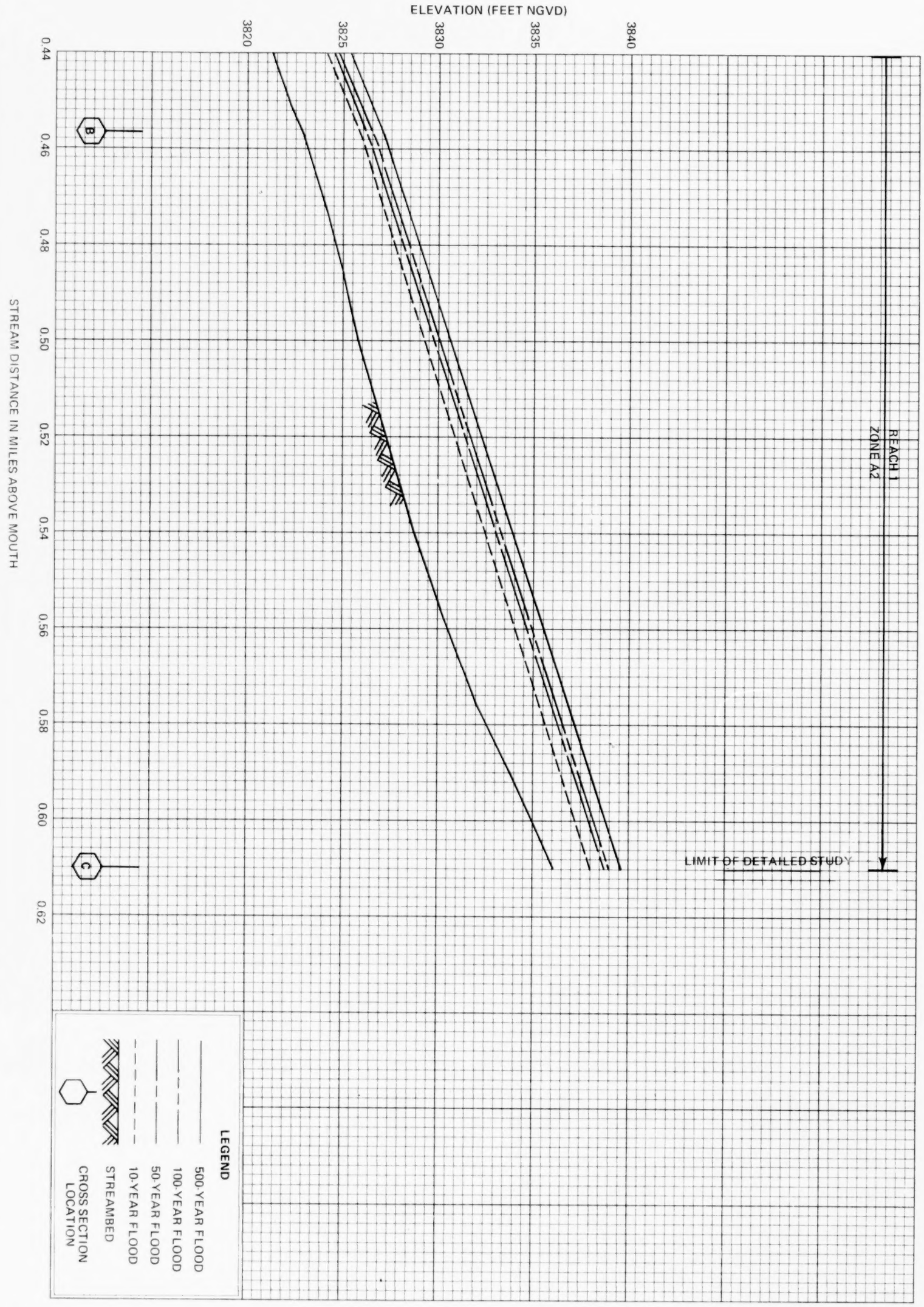
FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

67P



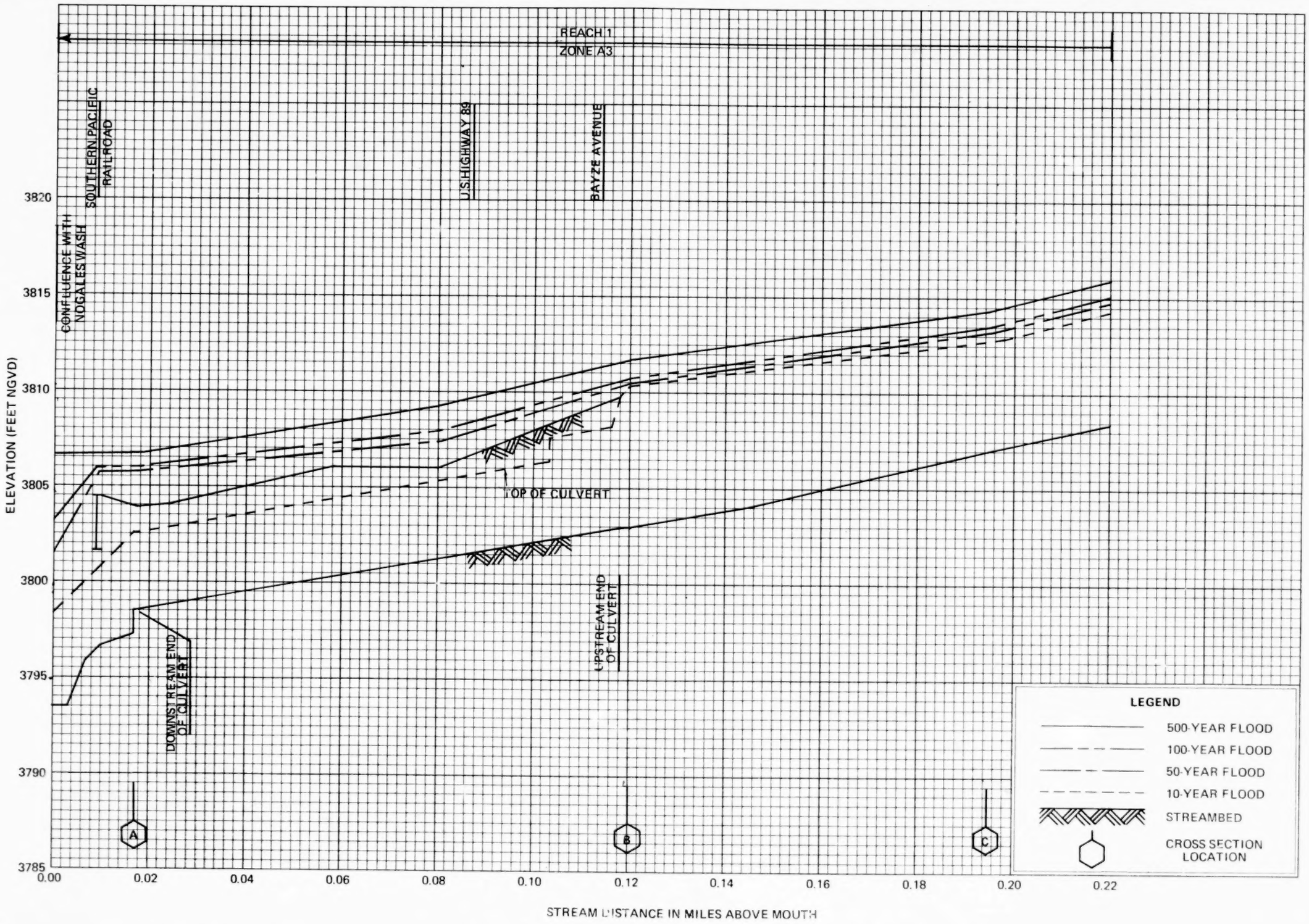
68P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

MARIPOSA CANYON TRIBUTARY NO. 2



FLOOD PROFILES

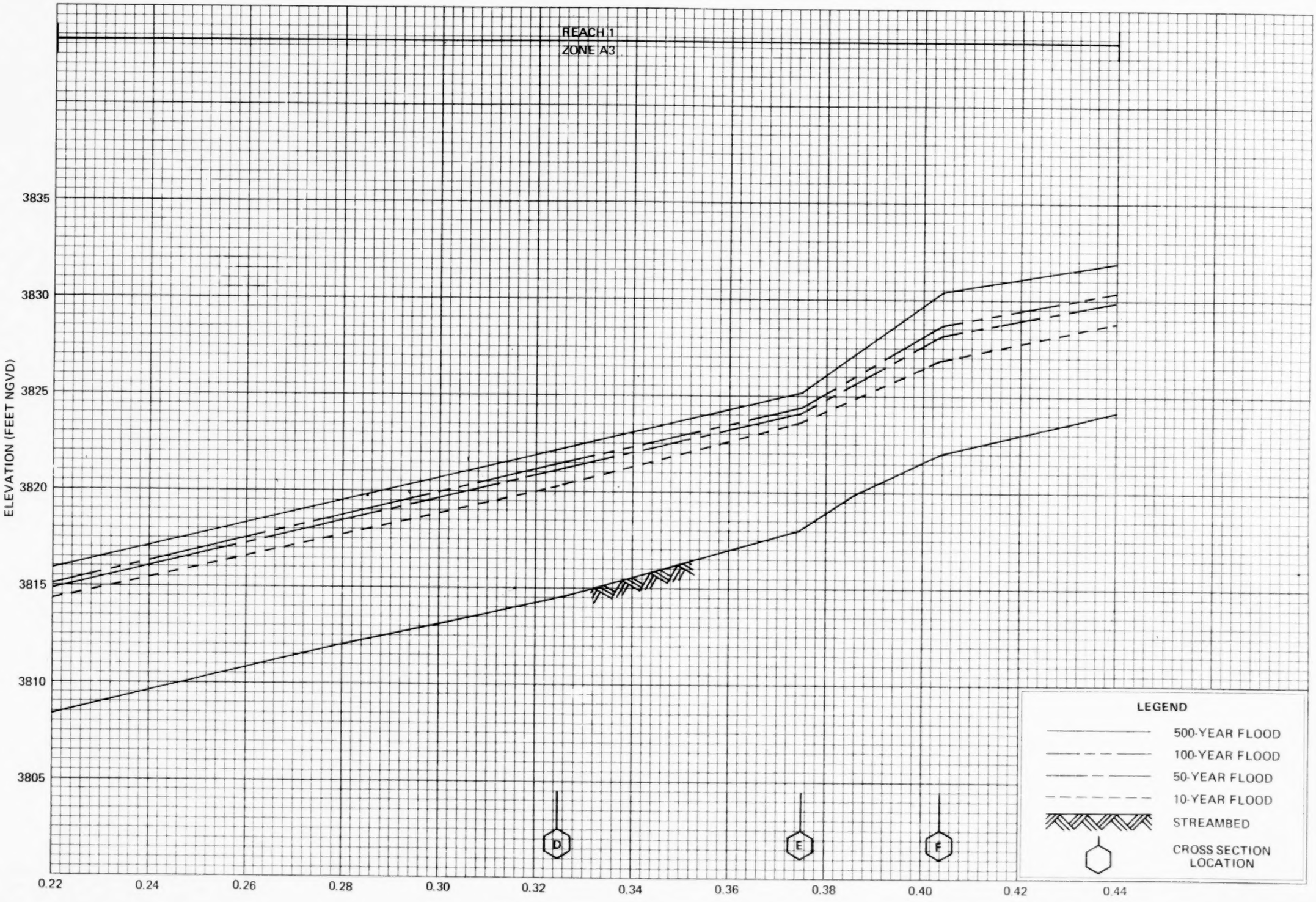
EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ

(SANTA CRUZ CO.)

69P



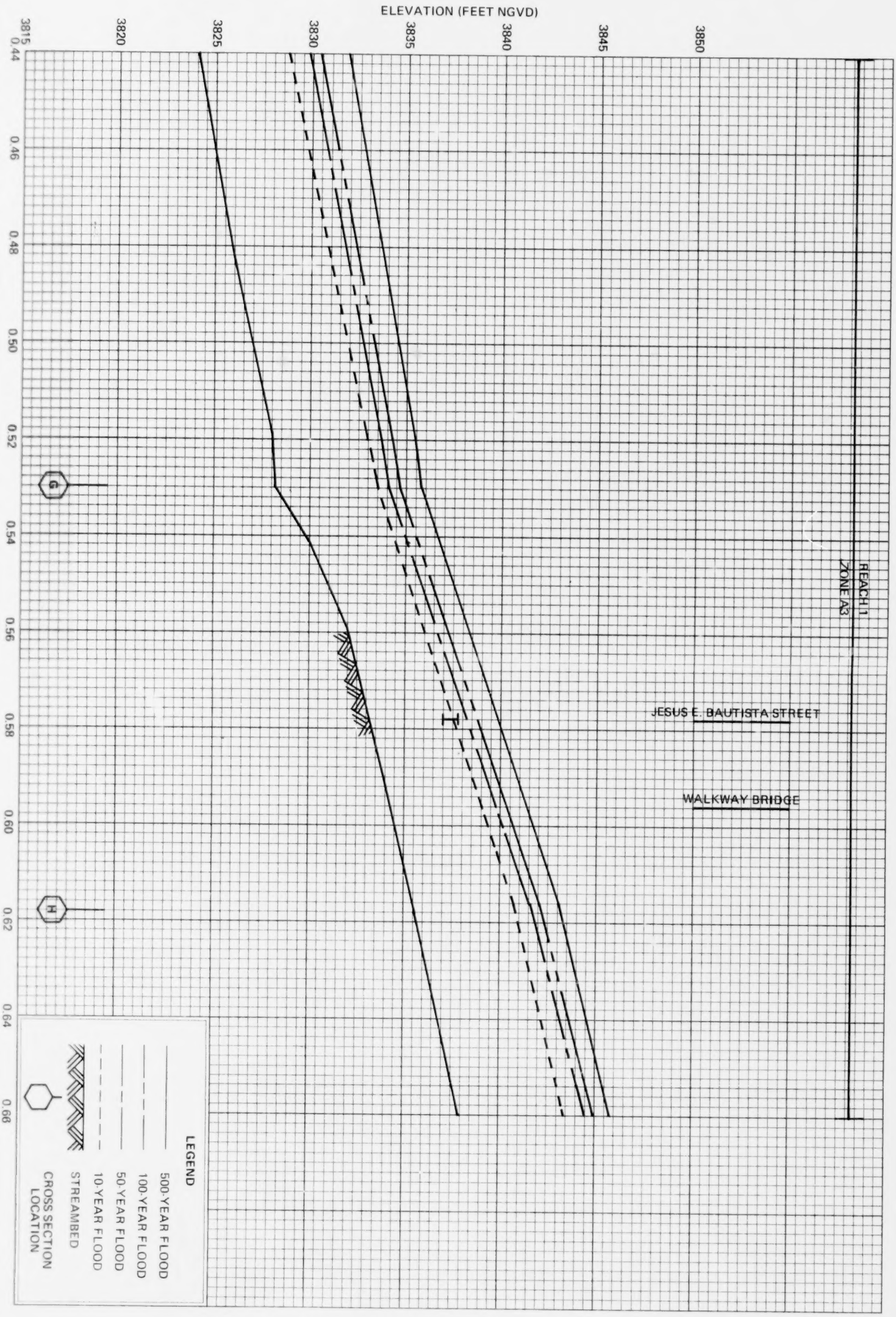
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

70P



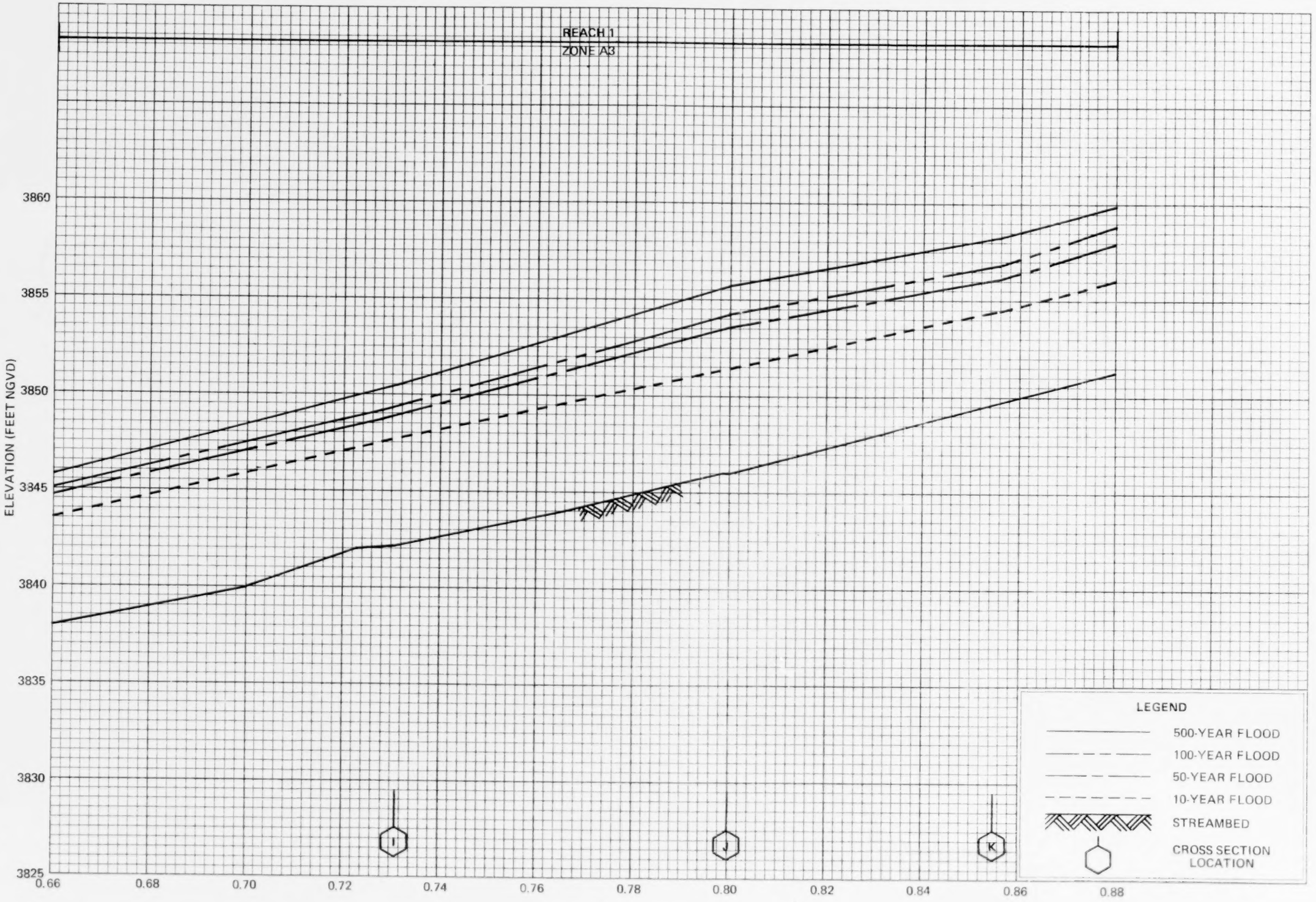
71P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

EPHRIAM CANYON WASH



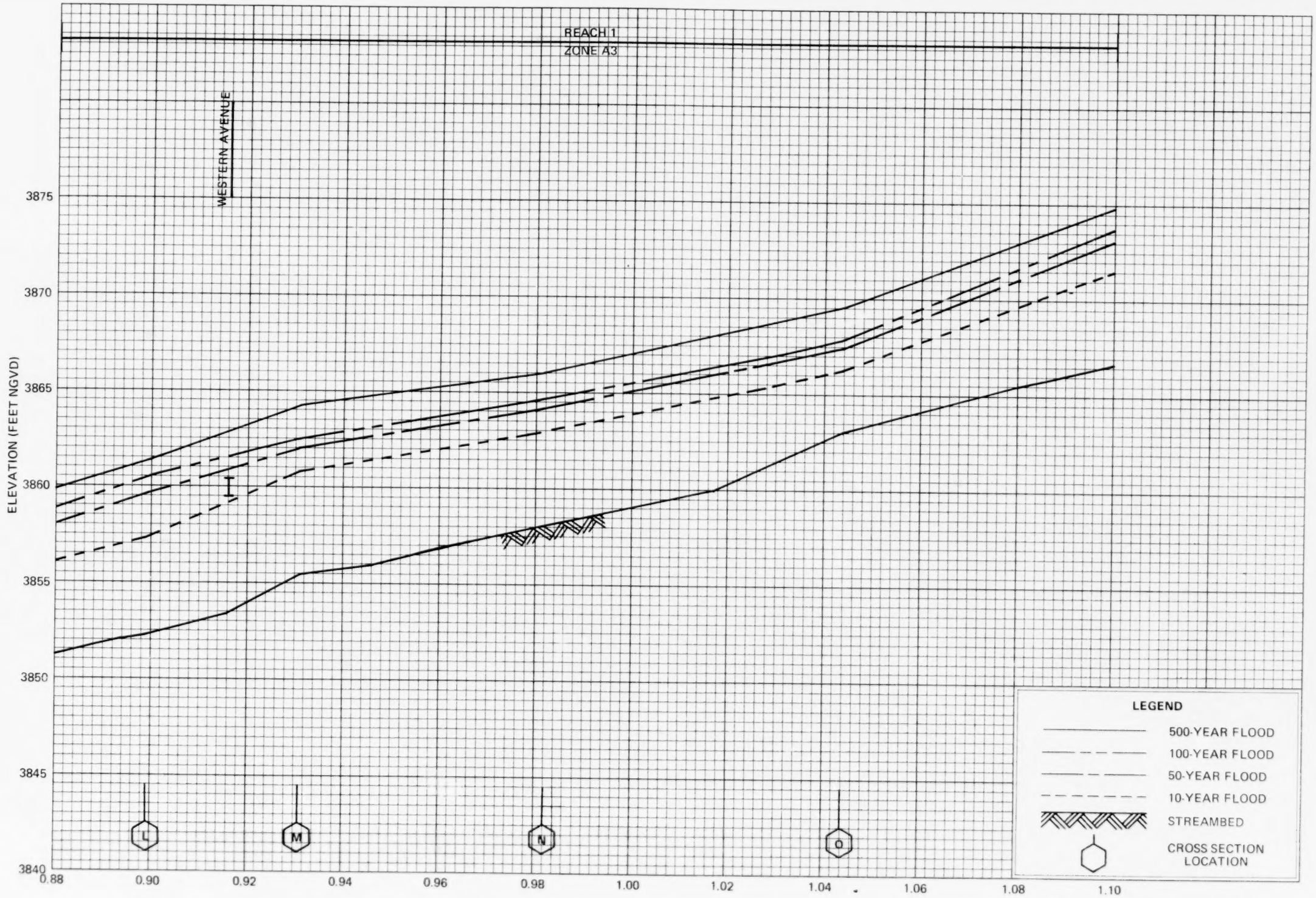
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

72P



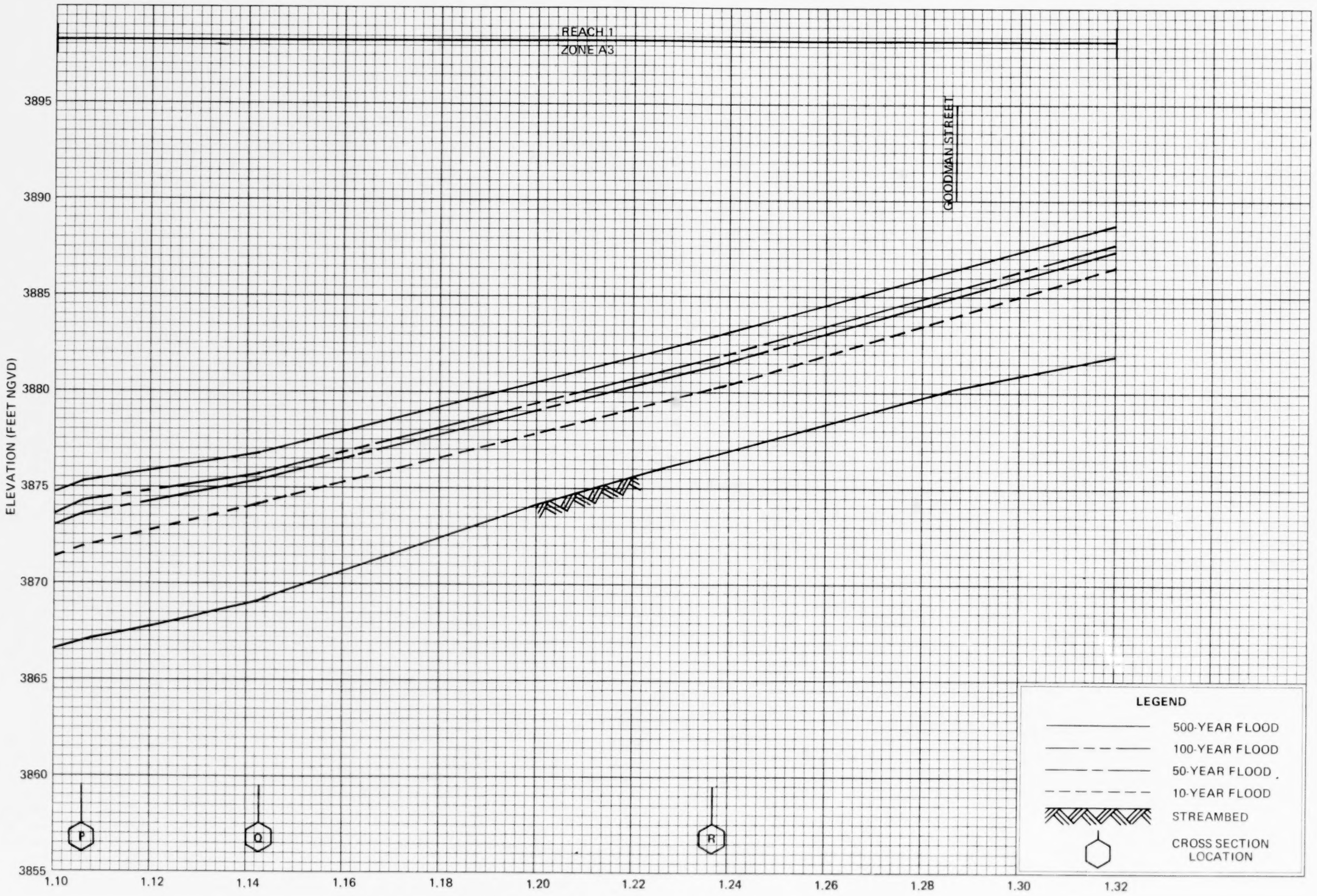
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

73P



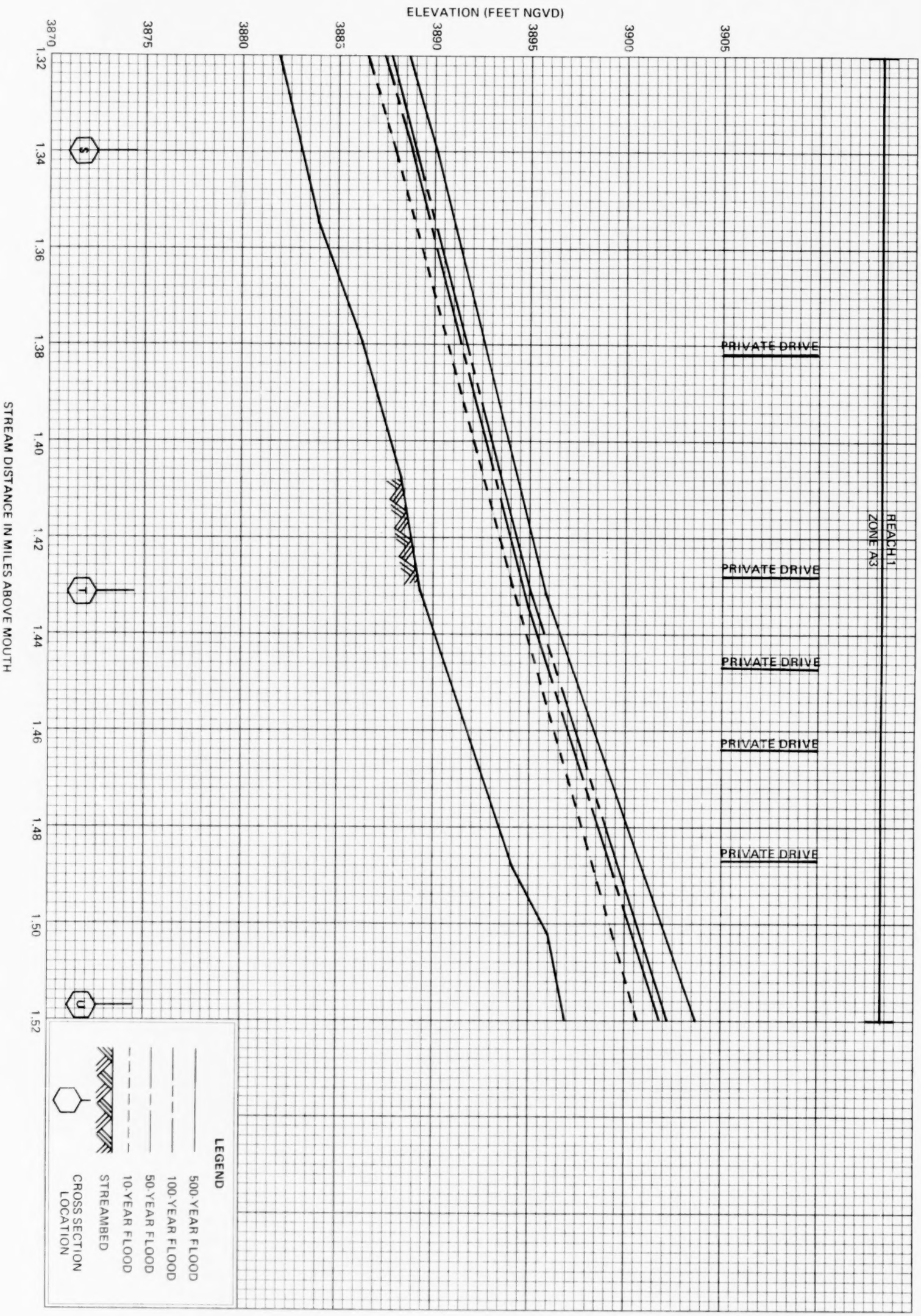
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

74P



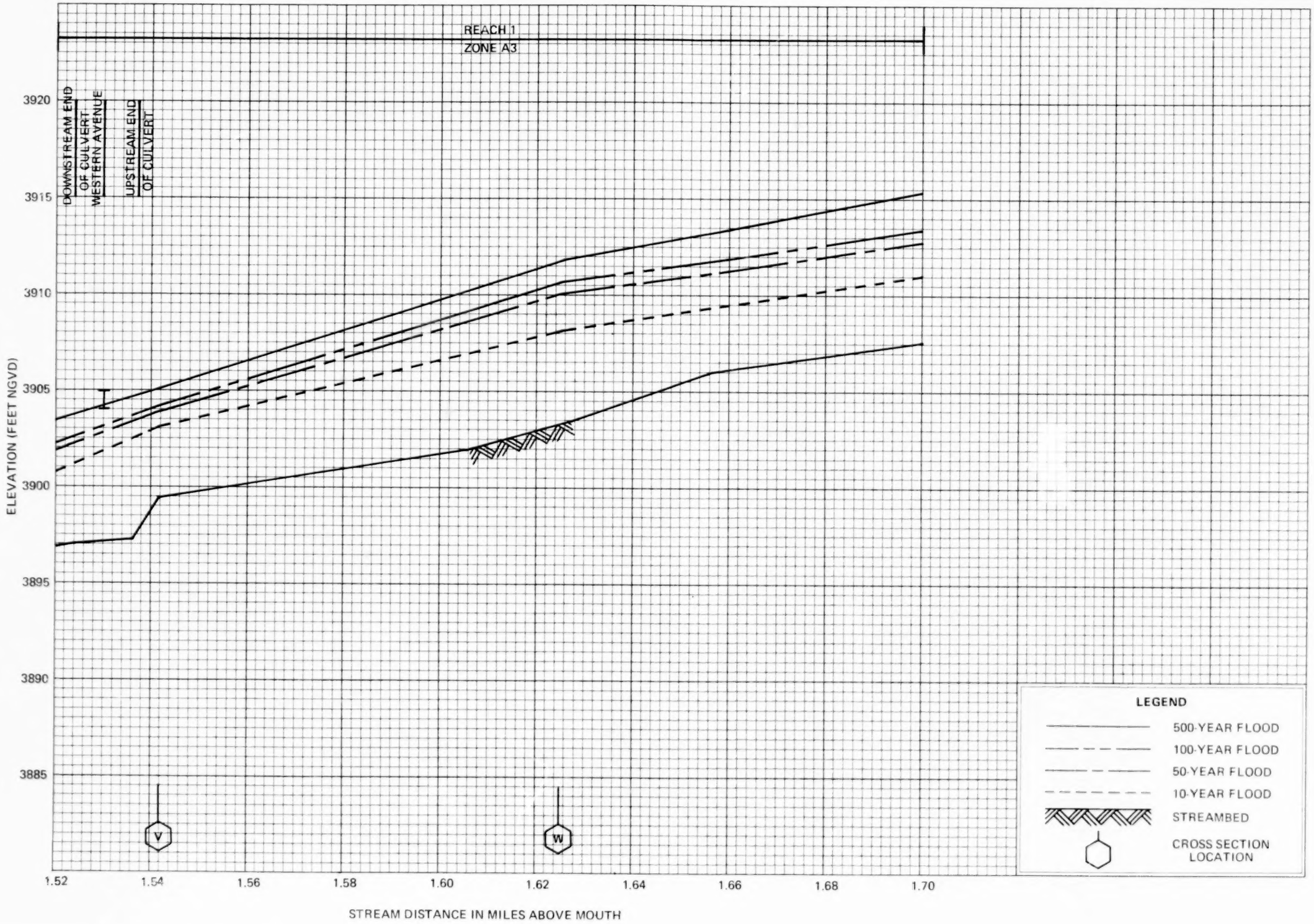
75P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

EPHRIAM CANYON WASH



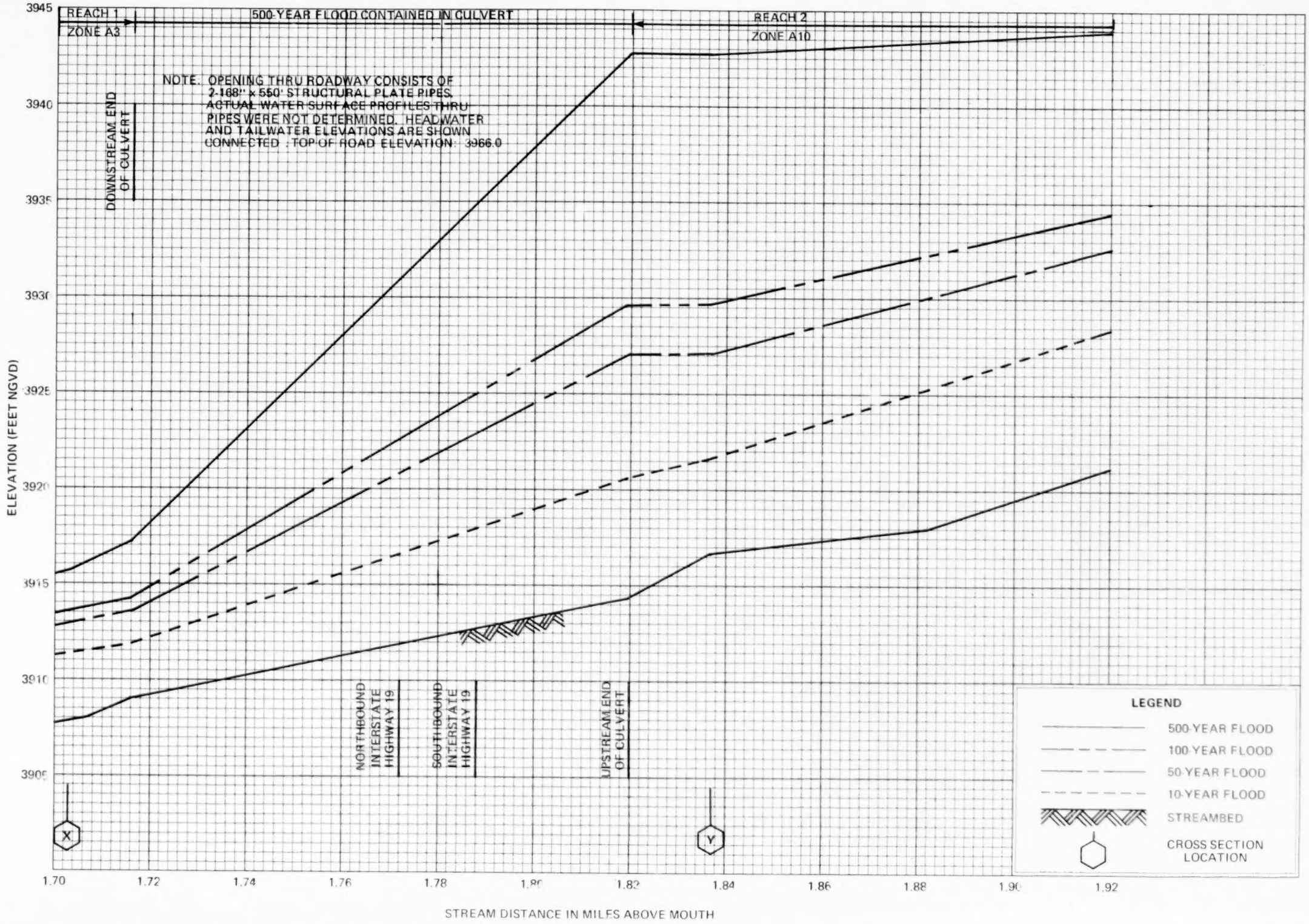
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
[SANTA CRUZ CO.]

76P



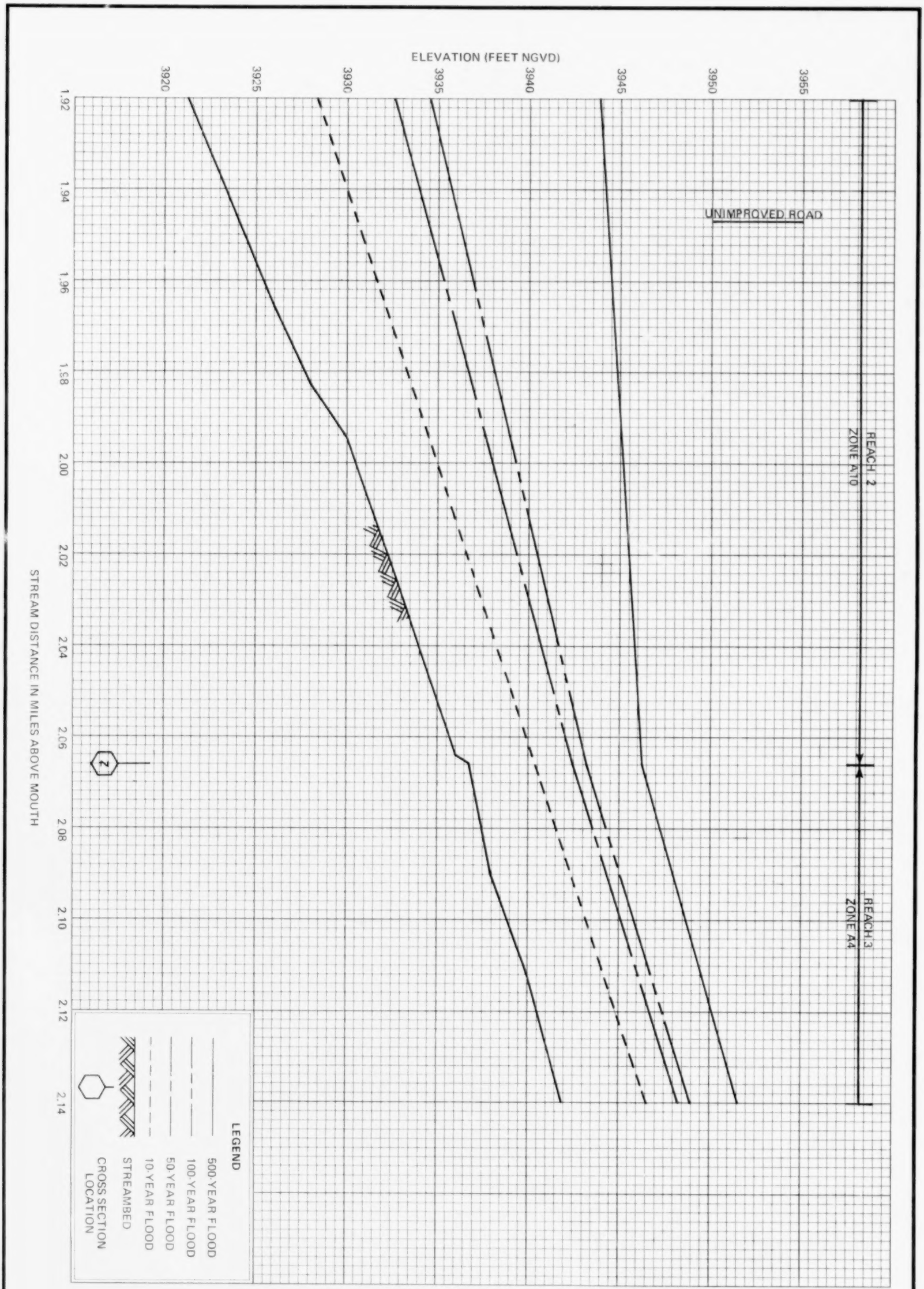
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

77P



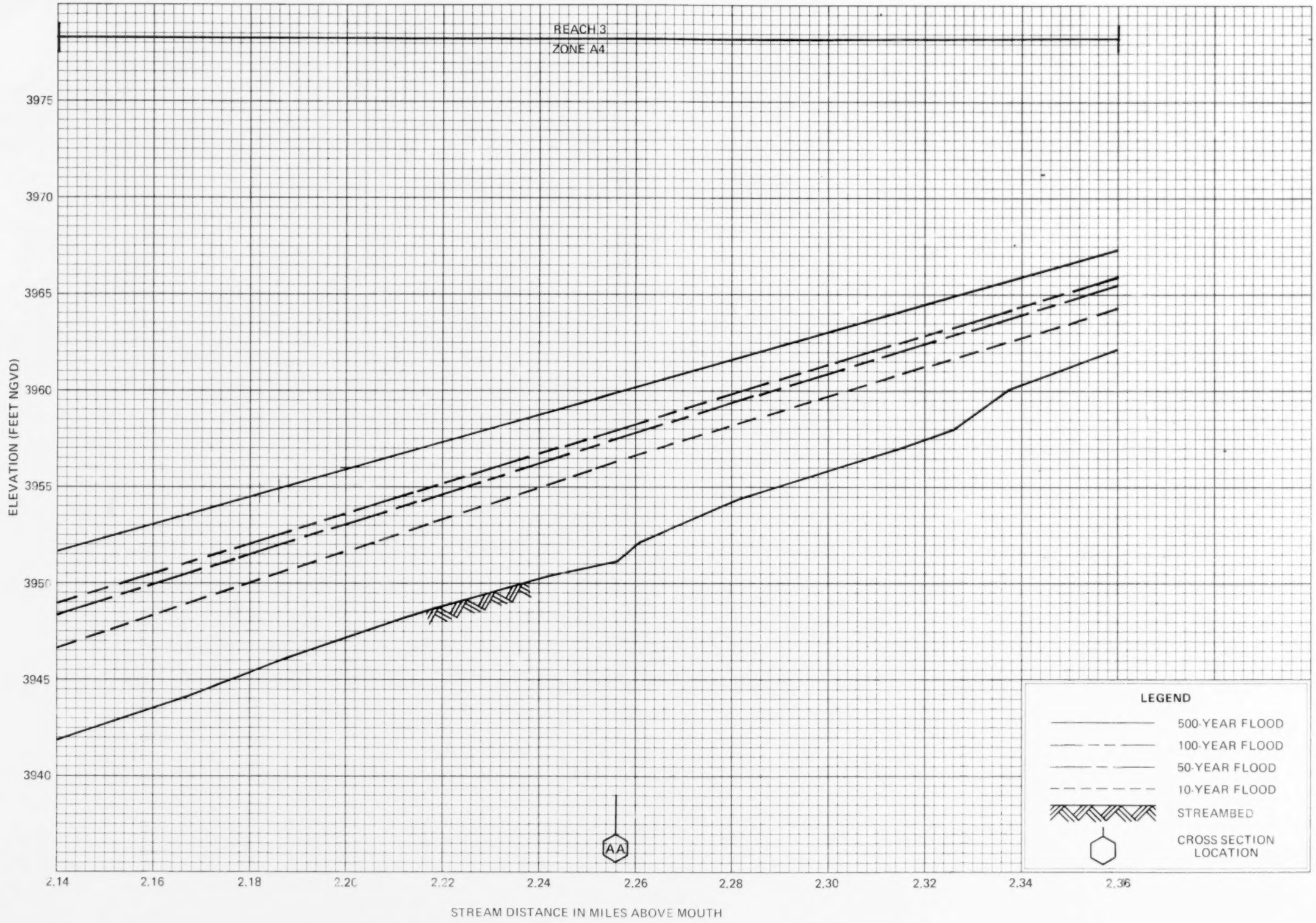
78P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

EPHRIAM CANYON WASH



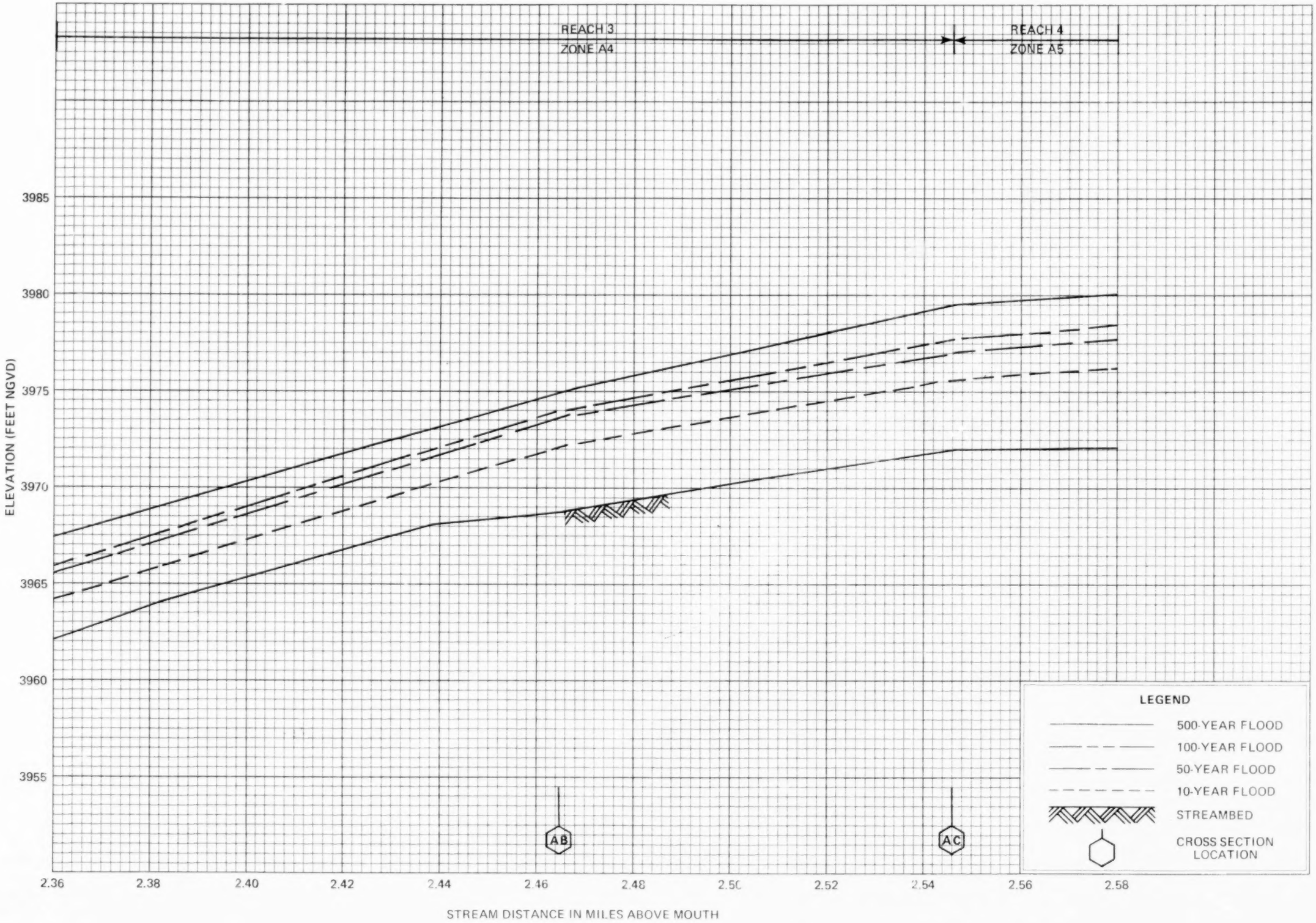
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

79P



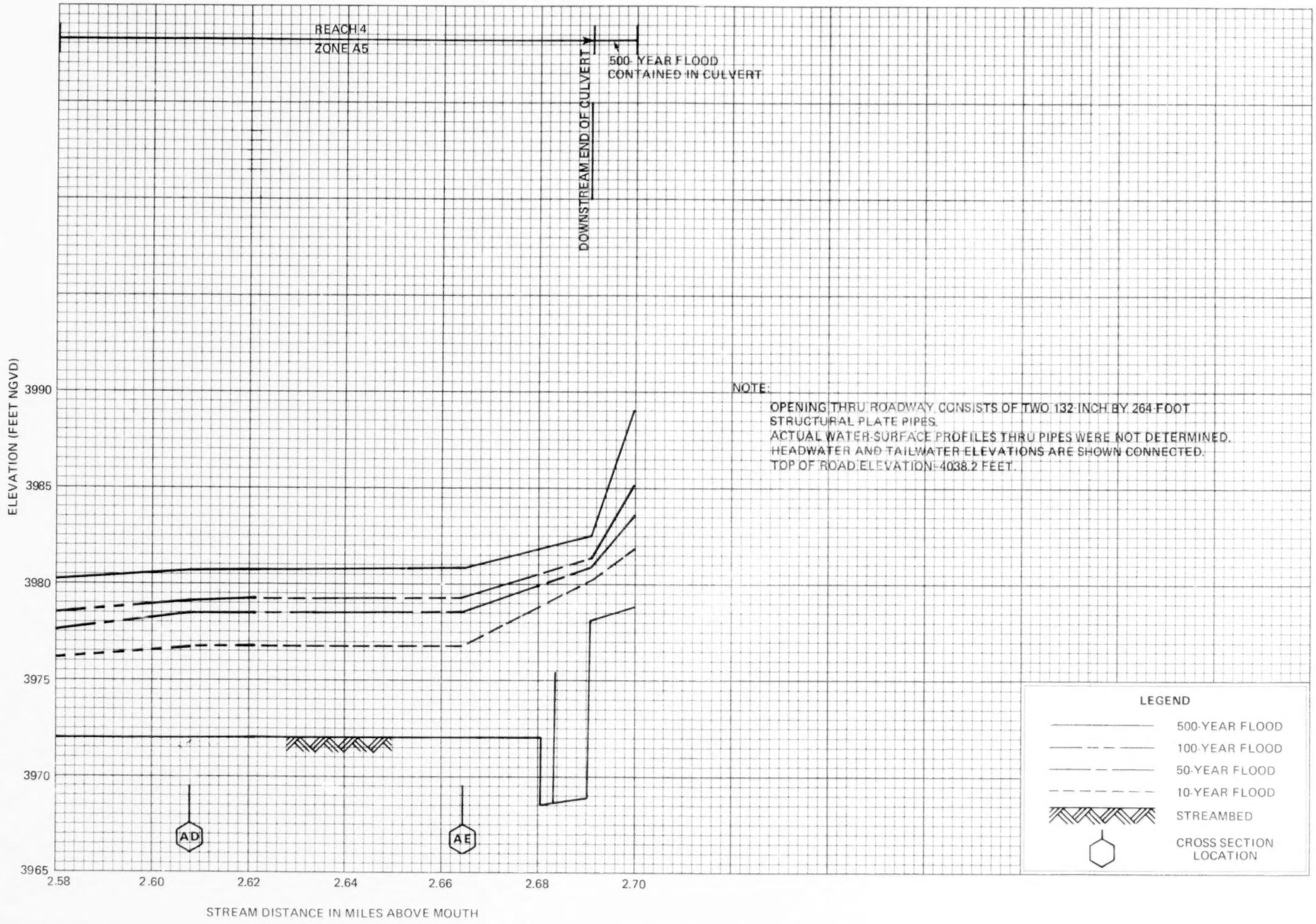
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

80P



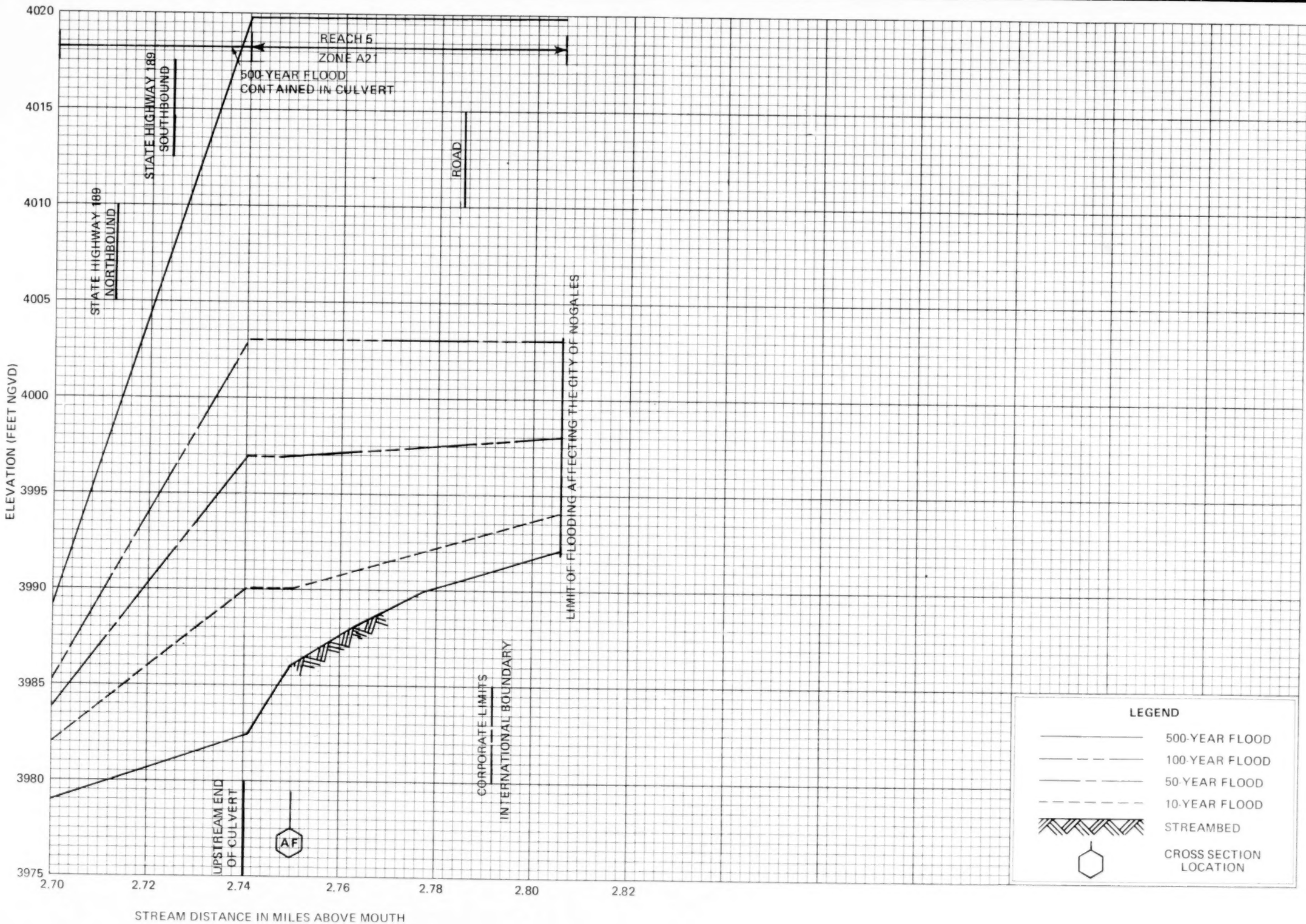
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

81P



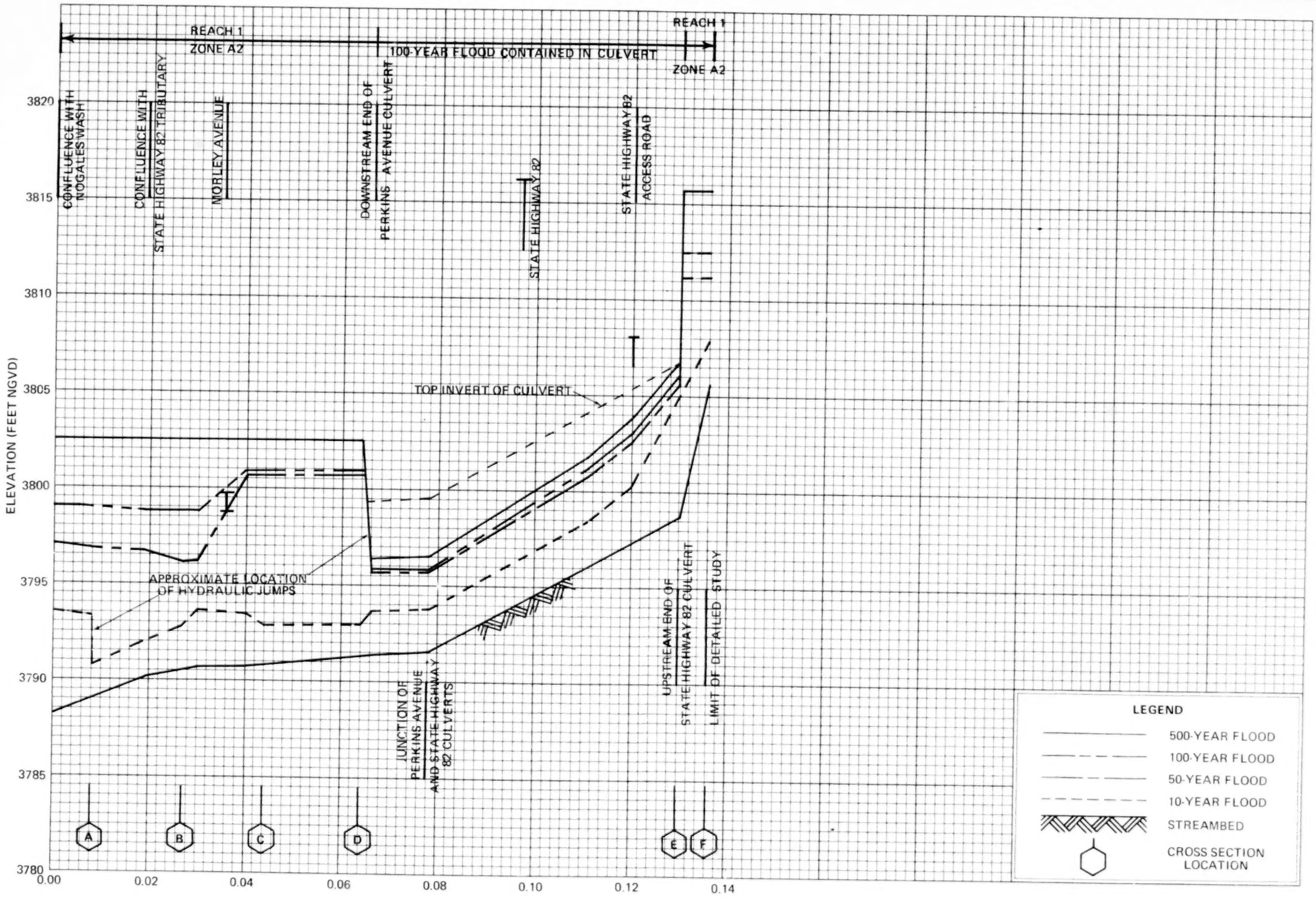
FLOOD PROFILES

EPHRIAM CANYON WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

82P



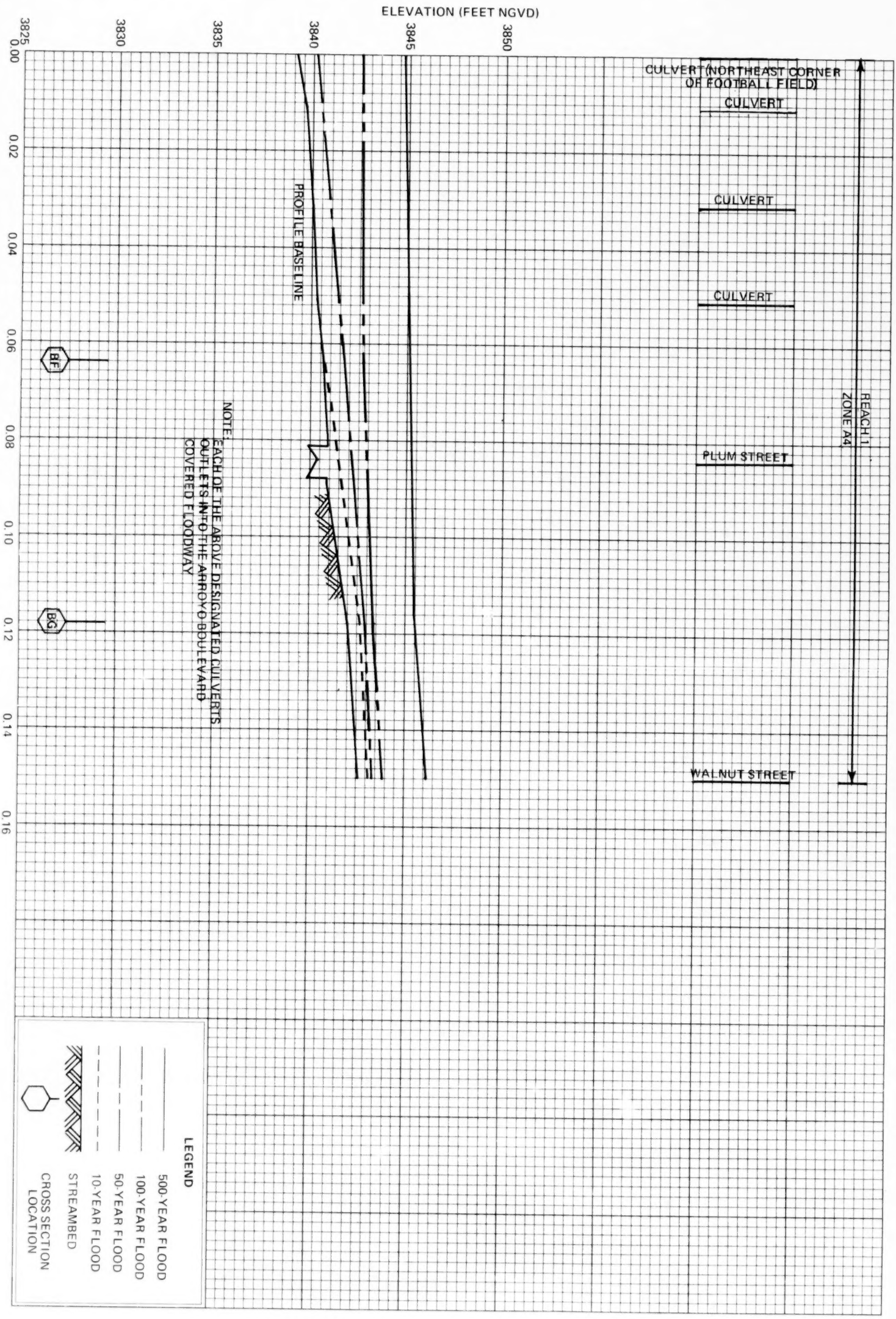
FLOOD PROFILES

FALLS WASH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

83P



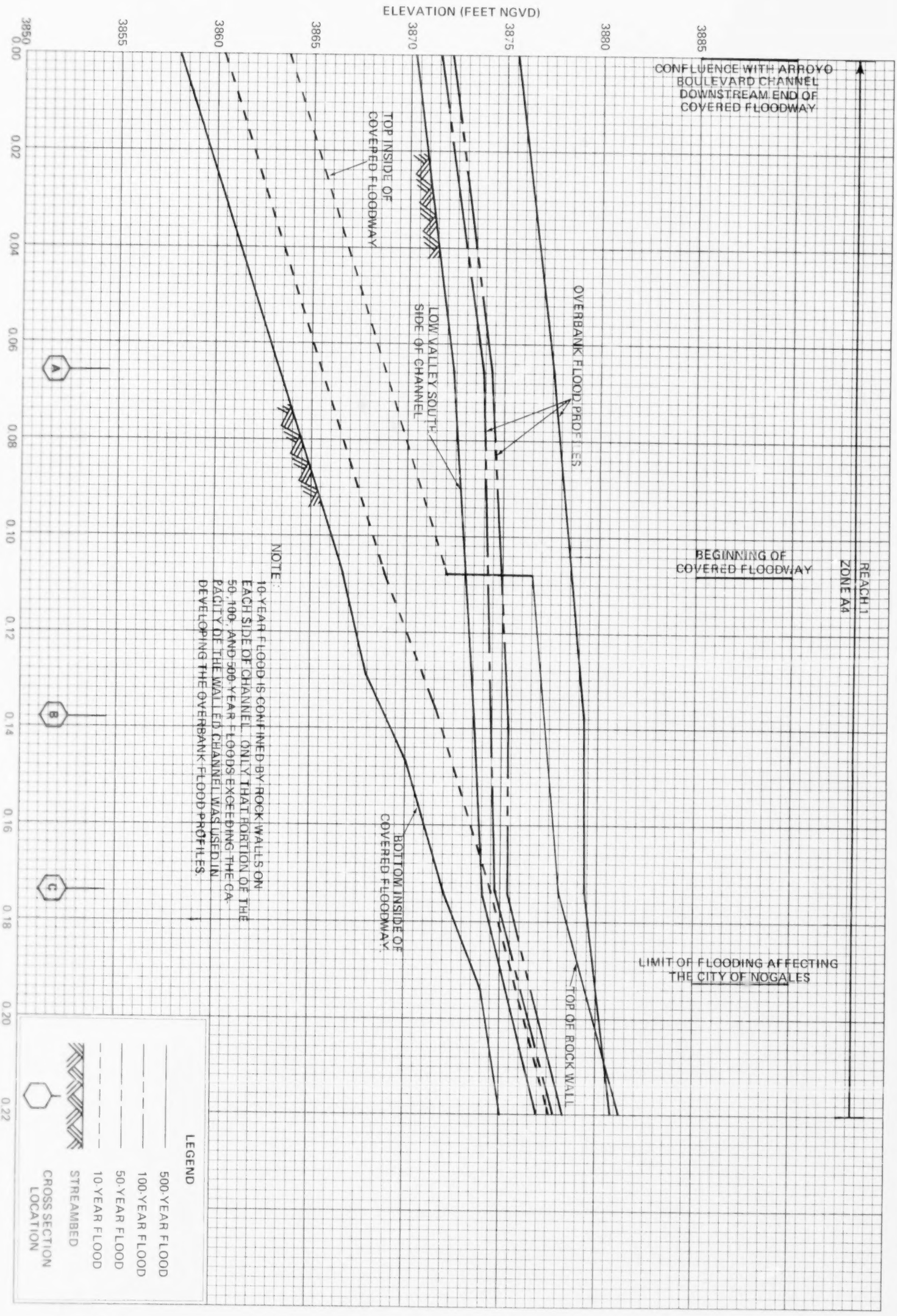
84P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

FLOOD PLAIN AREA WEST OF ARROYO BOULEVARD
BETWEEN QUARRY AND WALNUT STREETS



85P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF NOGALES, AZ
(SANTA CRUZ CO.)

FLOOD PROFILES

INTERNATIONAL BOUNDARY CHANNEL